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Spare Parts

At no period in history has the importance of spare parts been impressed upon the minds of people more than at present. This is the direct outcome of a couple of decades of mass production. Amongst makers of foundry machinery, some have already achieved a fine reputation for the rapid supply of spare parts of high quality and dimensional accuracy; others still have to achieve it. Now it so happens that many spare parts are castings and that their production will form an ever-increasing part of the output of the industry. Soon after VE-day we received a visit from a young man seeking to place orders, not for dozens, but for hundreds, and in a few cases thousands, of castings for sewing machines installed in this country, but of German origin. When we visit the Sheffield steelfoundries we see quite important castings being made as replacement parts for heavy German machinery. Moreover, some of these now in service are deemed to be superior to the imported originals.

A study of the pre-war statistics reveals that German industry was responsible for supplying the major engineering requirements of the Balkans and Southern Europe, whilst she shared the overseas market with Britain and America. The supply of spare parts for this vast volume of plant is a factor of major importance. There is but little prospect of much of it reaching this country, unless steps be taken to make it an attractive proposition for the buyer. In many cases this can be done when quoting for new plant, wherein as part of the service to be given is the supply of spare parts for machinery of foreign origin. It is just by offering this type of help that confidence between manufacturer and consumer is established and the basis for future business placed on a firm footing. It matters but little whether the manufacturer can or cannot make the spare part in his own concern, for under normal conditions the production facilities of this country are so vast and so elastic that a maker can be found.

We have reason to believe that what we have written will be appreciated by our wide circle of readers in the Dominions. We have noted during the war years how foundries located in remote parts of the Empire have not merely supplied spare parts for machinery imported from all over the world, but by employing modern technique have actually furnished a superior article. For instance, one foundry in Rhodesia is making links for stoker grates of special heat-resisting irons, which are giving better service than the plain irons previously obtained from Europe. Sometimes, in their youthful enthusiasm, they replace a 20-year-old casting by one made in " special iron " by patented processes developed both here and in America, and " crow " about its superiority, forgetting that in two decades corresponding progress has been made elsewhere. Yet we cannot help but admire the resolute courage with which they have solved their problems.

As a potential market for the time when pressure upon the foundry industry is eased, the supply of spare parts for machines made by now non-existent German factories is amongst the most attractive, but it will require all the business acumen the sales department can assemble to attract this type of order. The effort will, however, be worth while.

COKE SUPPLIES

As there seems to be a possibility or probability of coke supplies to foundries being cut next spring, the Council of Ironfoundry Associations have sent to the Ministry of Fuel and Power a well-reasoned letter pointing out all the implications involved should a cut be imposed—especially on the housing, reconstruction, export and all other industrial activities.

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FORTHCOMING EVENTS

(Secretaries are invited to send in notices of meetings, etc., for inclusion in this column.)

NOVEMBER 15.

Institution of Mechanical Engineers:—Thomas Hawksley Lecture—"Unexploded Bomb Disposal," by Dr. H. J. Gough. At the Institution, Great George Street, London, S.W.1, at 5.30 p.m.

NOVEMBER 18.

Sheffield Society of Engineers and Metallurgists:—"A Consideration of Liquid Fuel Firing, with Particular Reference to Open-hearth Furnaces," by F. A. Gray. At the Royal Victoria Station Hotel, Sheffield, at 6.15 p.m.

Society of Chemical Industry (London section):—Jubilee memorial lecture: "British Chemical Publications," by F. P. Dunn. At the Royal Institution, Albemarle Street, London, W.1.

NOVEMBER 19.

Sheffield Metallurgical Association:—"Statistical Analysis of Steel-making Data," by N. H. Bacon. At the Metallurgical Club, West Street, Sheffield, at 6.30 p.m.

NOVEMBER 20.

Institution of Production Engineers (Sheffield section):—Discussion: "Some Production Engineering Problems." At the Royal Victoria Station Hotel, Sheffield, at 6.30 p.m.

NOVEMBER 21.

Institute of Fuel (Yorkshire section):—Brains trust on "Fuel Conservation." At the Royal Victoria Station Hotel, Sheffield.

NOVEMBER 22.

Institute of Physics (Industrial Spectroscopic group):—Annual general meeting. "The Spectrographic Analysis of High-purity Materials," by D. M. Smith. In the Department of Applied Science, the University, St. George's Square, Sheffield.

Institution of Mechanical Engineers:—Informal meeting. At the Institution, Storey's Gate, London, S.W.1, at 5.30 p.m.

Manchester Association of Engineers:—"The Future of Agricultural Engineering," by W. H. Cashmore. At the Engineers' Club, 17, Albert Square, Manchester, at 6.45 p.m.

Institute of British Foundrymen

NOVEMBER 16.

East Midlands branch:—"Refractories," by A. T. Green. At the Technical College, Derby, at 6 p.m.

NOVEMBER 23.

Bristol and West of England branch:—"Recent Visit to American Foundries," by T. Makemson. At the Grand Hotel, Broad Street, Bristol, at 3.30 p.m.

FOUNDRY TRAINING SCHEME

We have been privileged to examine some draft lay-outs of educational posters covering foundry moulding practice. Of the 18 posters being prepared we have examined eight, and we deem them to be excellent for arousing the interest of the youth in his craft. They appear to us as though they are to be produced by three-colour printing, and although not outstandingly artistic, are at least very attractive. We feel sure they will receive the full approbation of the industry and the teaching profession. These tentative designs have been produced under the ægis of the Council of Ironfoundry Associations, and a later statement will announce their acceptance and availability.

CORRESPONDENCE

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

SOURCES OF HYDROGEN IN CAST IRON

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—It now appears that the validity of Mr. Tucker's theory rests on the supposed presence of an unweighable quantity of moisture. That is, moisture in the form of dry steam equal in volume to the pore space in coke. This volume, he shows, could supply enough hydrogen to give his 2 c.c. of hydrogen in his small test sample of metal. The coke samples used in my tests were about 5 in., such as is common in cupola charges, and the accuracy of weighing ± 0.022 per cent. (In laboratory tests on moisture we use a balance which weighs to ± 0.00003 gms.)

Referring to Mr. Tucker's small calculations, the moisture which could be left in the above tests (but I feel sure was not) would represent a possible 0.2 c.c. hydrogen, instead of 2 c.c. in Mr. Tucker's small metal sample. Next, admitting that expansion takes place, a rise from atmospheric temperature to the region of 1,500 deg. C. would cause an expansion to six times the original volume, and so in the pore space the possible available steam would represent one sixth of the original possible hydrogen. This is equivalent to 0.033 c.c. of hydrogen in Mr. Tucker's small metal sample, instead of 2 c.c. Further, if we allow for diffusion, this process of elimination will be carried further.

Mr. Tucker tells us that glass surfaces cannot be dried, even at high temperatures, but if coke cannot be dried at 526 deg. C. the same reasoning applies to Mr. Tucker's sampling tube, treated with spirits of salts, boiling water, 5 per cent. sulphuric acid, and finally dried at 150 deg. C. If he claims this tube to be free from moisture and hydrogen, he must allow us to claim that the coke sample heated to a constant weight ± 0.022 per cent., is dry. This being so, we have disposed of water due to rain, that sucked in during quenching, and lastly steam, and we again come to the conclusion that water in coke is of no importance in the search for dissolved gases in cast iron.

I am sure that the method of Hatfield and Newall will receive due attention from the Combined Committee on Gases, with a proper amount of duplication before decisions are given. Although Mr. Tucker's theory may not be acceptable, we are nevertheless indebted to him for affording the opportunity for an interesting discussion.

Yours, etc.,
W. Y. BUCHANAN.

"Dunconnell,"
Thomson Avenue,
Johnstone.
November 6, 1946.

AN INDEX of the "Enamelist," volume 22, that is from October, 1944, to December, 1945, inclusive, is now available on request to Ferro Enamels, Limited, of Wombourne, Wolverhampton.

A SIMPLE RAPID METHOD FOR DETERMINING THE MOISTURE CONTENT OF SAND*

Describes a method based on electrical properties

By P. D. LIDDIARD† and ELIZABETH SEAL‡

To the conscientious foundryman, the continual checking of the moisture of the moulding sand is an essential part of foundry routine. The "feeling by hand" method of the old moulder, while still respected when it is known that the moulder is a good man, is much discredited since it can so easily give a false impression of the sand condition. A sand, having a low amount of bonding constituents, but high moisture content, can readily be accepted by those not too well accustomed to the feel of moulding sand, and such a sand would obviously be a possible cause for subsequent trouble in the casting. Additions which are now made to moulding sand can further confuse this assessment, and the rule of thumb is a poor method compared with the use of the more up-to-date apparatus now available. In this article the Authors suggest further improvements which make sand testing even more reliable and rapid.

Earlier Methods of Moisture-in-Sand Testing

The first method of water determination which suggested itself was that practised for most general water estimations, namely, drying the substance at a temperature somewhat above that of the boiling point of water and determining the loss in weight directly. The method is obviously slow and can only be used on a small scale, but it has the advantage of accuracy. Precautions are necessary, however, even though the method is apparently straightforward. The moulding sand contains clay, associated with the silica grains, and the water is normally associated with this clay. Some of the water is loosely associated, while some forms part of the molecule of the clay. Clay, being a complex alumino-silicate or mixture of silicates, only has a plasticity in the hydrated state. This combined water is not readily removed. Nevertheless it plays a very important part in the bonding quality of the sand. If attempts are made to determine the total water content by high temperature water evaporation, decomposition of other constituents of the sand may occur and give false results. This is particularly applicable to sand containing mixed coal dust.

The principal disadvantage of this simple drying method is its slowness, thus limiting the number of samples of sand which can be checked, or are likely to be checked in a busy foundry. The method has been speeded up by the use of hot air for drying and a compact apparatus is on the market. There are several designs of this, but in all, air, heated electrically and driven by a fan is passed through a sample of the sand in a suitable pan, the water being evaporated more quickly than by direct heating. Again direct weighing is employed. Even though the time taken is far less than by the simple drying method, it is still an operation which, in practice, limits the number of samples which a foundryman can take. Again, the sample should be representative of the mass of sand being used and without laborious sampling precautions, this can hardly be expected to be the case.

The "Speedy" moisture tester is more rapid and is deservedly popular in this country. It permits the water to react with calcium carbide and the acetylene evolved creates a pressure in the reaction chamber which is measured on a gauge calibrated directly in terms of moisture content. More samples may be taken in a given time than by the other methods so far described. Normally the method operates satisfactorily for most sands, but like all other methods it is not entirely independent of sand composition. Again, unless several samples are being taken, the sample of sand to be tested should be representative of the whole sand supply, which often is not the case, and a false impression can easily be obtained by the operator in this way. The apparatus does require a certain amount of skill to use and cannot be left to any heavy-handed labourer; but it is nevertheless much more robust and requires far less skill than other methods previously described.

Limitations of These Methods Which Might be Overcome

The principal factor in improvements is one of time, not accuracy. With a more rapid method, more samples can be tested, and a somewhat less accurate determination on four or five samples taken from a sand pile gives a more useful picture than one very accurate determination of a sample which cannot be considered as representative of the whole pile. It was with this object in view that the apparatus for rapid sand testing was developed. It has since come to the notice of the Authors that apparatus based on a similar principle was developed in the U.S.A. some years ago, and a few instruments were sold in this country. The supplementary incentive to the present development is the continuous testing of sand in a circulating system, and in this respect there is originality, for the previous methods were merely for simple hand testing. Nor were the non-electrical ones, described briefly

*Provisionally patented.

†Chief metallurgist, Glacier Metal Company, Limited.
‡Chemist, Glacier Metal Company, Limited.

Determining Moisture Content of Sand

above, suitable for continuous testing, whereas the method to be described can be readily adapted for this purpose.

Development of the Electrometric Method

Previous experience in the use of conductivity methods for the determination of the concentration of various electrolytes in solution led to the thought

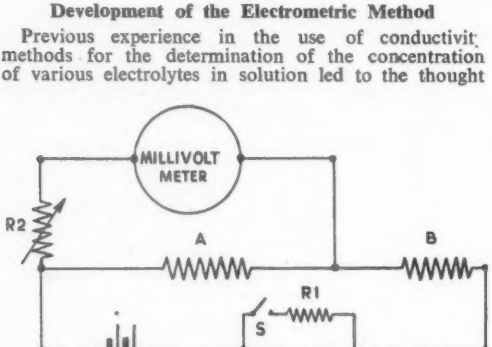

FIG. 1.—THE CIRCUIT.

that the method could be applied to the measurement of small quantities of water in sand. Normally, dried sand cannot conduct an electric current, but the presence of moisture will create a current carrying capacity, and this conductivity will increase with rise in moisture content after the moisture becomes a continuous phase. The increase will be in direct relationship with the amount of water present, since the resistance to the conduction of the current will fall as the thickness of the water film around the particles increases. In the foundries where the initial tests with the apparatus were made, the moisture content was maintained for various moulding purposes at points between 6 and 8 per cent., and it was soon found that a more constant value could be maintained with this method, since the number of tests taken could be so easily extended. The instrument was found to be sufficiently accurate for practical foundrywork in a range of 2 to 12 per cent. of moisture, although, as already indicated, this is a far greater range than is required. The instruments are now in constant daily use, and give far less trouble and discounted results than previous methods employed.

The Circuit

The essential features of the circuit are a constant potential difference across the two steel plates, and a means of measuring the current flowing from plate to plate when they are buried in the sand. In addition, it is desirable to have some means of checking the instrument so as to correct for changes in the source of current. The actual circuit is shown in Fig. 1. A two cell, 3 volt, dry battery is used as the source of current, and a standard millivoltmeter measures the potential difference across a resistance in the main circuit, this providing a measure of the current flowing. For checking purposes a switch "S," which connects a resistance "R1" across the plates, is used. The value of "R1" is chosen as being the resistance of the sand under test at some known water content, say 6 per cent. With the switch closed and the plates away from the sand the instrument should clearly read 6 per cent., and if it does not do so, it can be corrected by means of the variable resistance "R2," which is in series with the millivoltmeter.

Construction of the Unit

The whole circuit is placed in a wooden box with a hinged lid (see Figs. 2, 3 and 4). A convenient size is 7 in. by 4½ in. by 5 in. deep. Through the base of the box protrude the two dip plates. These can be made of steel, and are placed parallel. On one instrument they are 3½ in. long, 1½ in. deep, and ⅛ in. thick, firmly fixed 1⅛ in. apart, through the bottom of the box.

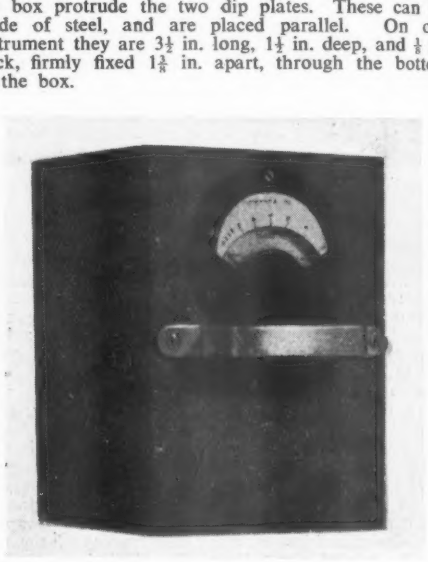

FIG. 2.—VIEW OF THE TOP OF THE INSTRUMENT, SHOWING THE HANDLE AND METER CALIBRATED IN WATER CONTENT.

The flush mounting millivoltmeter is mounted in the lid of the box, as are the checking switch and correcting rheostat. The controls for these latter should be deeply sunk in the lid to prevent accidental movement or damage. Batteries, resistances, etc., are all

housed in the box, whose lid should be screwed down to prevent sand getting in. It will only need opening at long intervals for changing the battery.

Calibration and Use

Four or five samples of sand of known moisture contents are made up, the moisture of at least one sample being adjusted to some value near that at which it is normally required to work when moulding. The moisture content can be accurately determined by the evaporation method. The plates are immersed in the sand sample having its moisture near the working point. The sample should be sufficiently large and in a suitable container to take the plates comfortably, and allow them to be well pressed down. The variable resistance is adjusted so that the millivoltmeter shows a convenient reading on the scale. Thus if it is calibrated from 0 to 100, and sand is used normally around 6 per cent. moisture content, a checking sample at 6 per cent. could be made to give a reading of 60 on this scale.

This is only meant to serve as an example, and it may be found preferable to adjust the reading to some other arbitrary point in the centre of the scale. The meter reading is marked on a calibration graph, against the appropriate moisture content. This is repeated for the other sand samples, but without, of course, resetting the variable resistance. If the points on the graph are now joined, a smooth curve should be obtained, which can be extrapolated if necessary. A blank scale is pasted onto the meter face and marked for the appropriate water contents, taking the equivalent millivoltmeter readings from the graph.

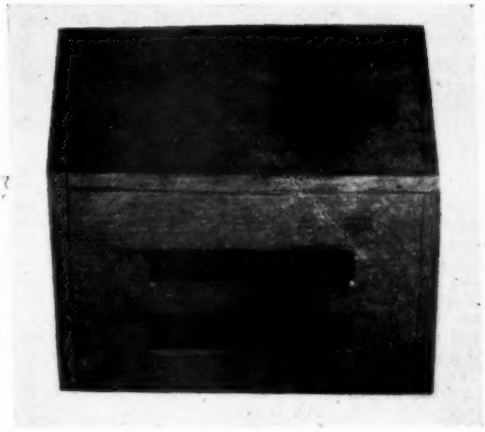

FIG. 3.—VIEW OF THE BASE OF THE INSTRUMENT, SHOWING THE PLATES IN POSITION.

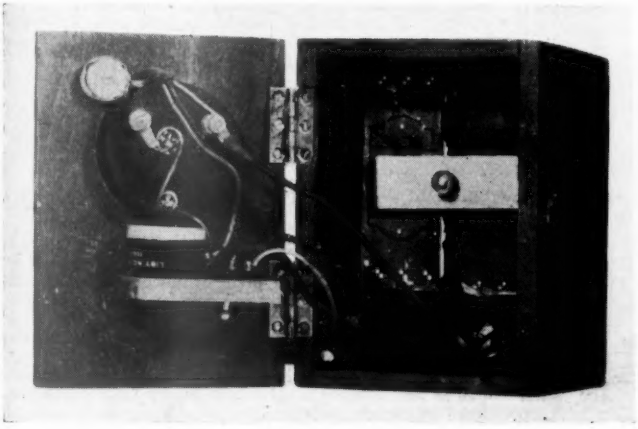

FIG. 4.—VIEW OF THE INTERIOR OF THE INSTRUMENT.

It may be found that adjustment of the variable resistance initially will not give a reading at a reasonable position on the scale. To correct this the resistance "B" can be varied; thus it has been found that for a soft water, having a greater resistance than a particular hard water, it is necessary to reduce the windings on "B." An alternative is to increase the contact area of the dip plates, and this may be found to be more convenient.

The use of the checking switch has already been explained. Having calibrated the instrument it is necessary to make up the checking resistance "R1" so as to give an agreed scale reading, say 6 per cent., with the switch closed and rheostat "R2" set exactly as for the calibration experiments. From time to time a check test can be made and the rheostat adjusted to compensate for any change in the battery condition. The unit is now fully calibrated and set. It can be used directly and should not require recalibrating unless a change is made in the type of sand used.

To obtain the moisture content of any pile of sand, the plates of the instrument are pressed firmly home into the sand, gripping the handle in one hand for the purpose; a direct and instant reading of the

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moisture content is obtained on the scale. The test can be repeated as often as desired in the same or a different pile of sand, merely making sure between each insertion that there is no sand from the previous test lodged between the plates.

Maintenance

The instrument can be made to be very robust, and some units which the Authors have had in constant daily use in a foundry for many months have shown little wear and have not yet required renewals of any parts, including the batteries. The removal of the sand from the plates will prevent them from rusting. Efforts should be made in the construction of the unit, and in its subsequent use to eliminate the chances of sand entering the box and damaging the millivoltmeter. As a further safety measure, the lid can be kept screwed down, only being opened when a new battery is required, or adjustment of the variable resistance for correction of the unit is necessary.

Limitations of the Instrument

Some limitations should be recognised. In the first place sand should always be checked at the same temperature as the original sample used in the calibration of the unit. Since moulding sand should be used cold, initial calibration, of course, is done with cold sand, and subsequent observations should be similarly carried out with cold sand only; the slight variations in room temperature do not affect the instrument reading to an appreciable extent. The sand packing might be considered a problem; but in practice it is found that, provided the plates are pressed firmly down into the sand, variations are not serious enough to affect the readings.

The non-moulding-sand constituents of the sand have an influence to a greater or lesser extent. Metal particles should not be numerous; but these would give a bad mould in any case. Added materials have little effect if they are non-electrolytes. But where they are electrolytes, falsely high readings can result. Thus addition of, say, bentonite, will not appreciably affect results, but soda ash in quite small amounts would make the instrument unusable. The water composition is important, and it has already been pointed out that a hard water will normally give higher readings than a naturally soft one, on the same instrument, unless calibration is adjusted to allow for the greater resistance of the soft water. Some of the earlier American instruments, using a similar principle, failed because of this, but the calibration of the present instrument can overcome this fault. On the other hand, artificially softened water may give higher readings, since sodium bicarbonate is a better conductor than calcium bicarbonate. However, provided the composition of the water does not appreciably vary, there should be little difficulty in this respect once initial calibration has been made.

Possible Developments

As described above, the unit is useful for determining the moisture content in sand in a moulding tub, or similar sand pile. However, it can also be adapted for incorporation in a continuously circulating sand system; and a further improvement can be effected in the regulation if the water addition to the sand is controlled by the instrument. Such regulations must take into account the rate of sand flow and the existing water content.

For this purpose a box having a false bottom opening at required intervals, and with an open top, receives all, or a constant proportion of the flowing sand. The dip plates are fixed in this box in such a way that the sand will not lodge between them. The opening base of the box has a counterbalance weight attached so that it will open when a predetermined weight of sand is in the box. This operation can be considerably improved and made more positive by the use of a solenoid operating when the sand in the box reaches a certain weight.

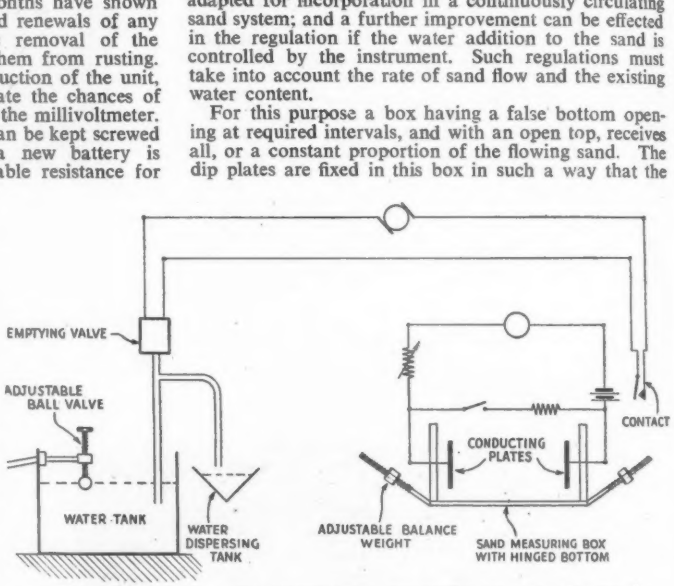

FIG. 5.—SHOWING THE UNDERLYING PRINCIPLE OF THE TESTER.

This opening and closing of the bottom of the box can in turn operate a valve in a supply from a constant head of water, permitting the addition of a defined volume of water to the sand every time the bottom opens, *i.e.*, a definite weight of sand passes through If this weight of sand can be varied as its water content varies, the added water will not only be adjusted to the rate of sand flow, but also to the

(*Continued on page* 271, *column* 2.)

FRENCH FOUNDRYMEN'S ASSOCIATION

TWENTIETH ANNUAL CONGRESS

The 20th annual congress of the Association Technique de Fonderie, was held last month in the Maison de Fonderie (Foundry House), Paris, under the chairmanship of Mr. Koehler, in the unfortunate absence of Dr. Paul Bastien, owing to illness. There was quite a sprinkling of Britishers present, including Mr. D. Howard Wood (President of the Institute of British Foundrymen); Mr. V. C. Faulkner (Editor, FOUNDRY TRADE JOURNAL); Mr. T. Makemson, M.B.E. (secretary of the I.B.F.); Mr. J. G. Pearce, M.Sc. (Director, British Cast Iron Research Association); Mr. A. G. Quarrell (British Non-ferrous Metals Research Association); Mr. S. Evans and Mr. W. H. Richardson (Langley Alloys, Limited, Slough), and Mr. E. H. Brown (Ministry of Supply).

The conference was opened by Mr. Olivier, the president of the Syndicat des Fondeurs (employers' federation). His welcome to the foreign delegations was particularly warm, and he was obviously proud of the present organisation of the French foundry industry. He specially referred to the Paris Foundry High School, which now had 45 students, and this for an industry of which the personnel was only 60,000! He took pleasure in reminding his hearers that they were meeting in the *Foundry House*, now no longer sufficiently large to hold the audiences which their meetings attracted.

He was followed by Mr. Richard, who is rapidly achieving a very prominent position in the French foundry industry. Eloquently he reviewed the present organisation of the industry and expressed confidence in the future, provided the individual foundries would utilise to the full the co-operative services available to them.

Technical Papers

The first Paper to be presented was from the Belgian foundrymen's association. Written by Mr. F. Boussard, it covered the question of foundry defects, and was an abstract of a 400-page report made by his association. A sharp division is made between defects arising from metallurgical consideration and those caused by the sand. Into the former category he places (1) Contraction; (2) castability; (3) suitability of the alloy; (4) inclusions (inherent in the alloy); (5) blow holes (inherent). In the second class he places (4) Inclusions (sand); (5) blowholes (due to the mould); (6) hot spots; (7) sand; (8) pressure on the moulds and cores; (9) wrongly-constructed moulds, and (10) various.

The author then classifies the defects according to their appearance, much as has been done in the Institute of British Foundrymen's Atlas, shortly to be published. The original Report should be of considerable value in establishing a standardised nomenclature.

Centrifugal Casting

The next Paper to be given was on the "Present Position of Centrifugal Casting," by Mr. J. Boucher, of Pont à Mousson. He reviewed the development of the process, and spoke of a French method which produced pipes 1.8 to 2 mm. (*circa* 0.25 in.) wall thickness. Third on the list was a Paper by Mr. Eyt, of Pamiers, who gave a practical review of the question of gases in iron and steel.

The first Paper to be presented after the luncheon interval was the British exchange Paper, "Standard Test-pieces for the Non-ferrous Foundry,"* prepared by Mr. Frank Hudson. An excellent summary was given by Mr. Marcel Ballay.

High-duty Cast Irons

Next was an important Paper on "High Tensile Cast Irons," by Mr. G. Delbart and Mr. R. Potaszkin. Their work covered the investigation of 12 types of irons of which two were plain, one a nickel-chrome, and nine nickel-molybdenum—all made in the basic electric furnace.

Plain Low-carbon (2.83 to 2.85 per cent.) Irons.—One of the two irons investigated was semi-phosphoric (P, 0.46 per cent.). Its properties were comparable with those of good pearlitic cast iron. The refined iron with low phosphorus was clearly better. The two irons were shown to be but slightly sensitive to thickness effect, and showed no particular tendency to draws and porosity defects.

Nickel-chrome Irons.—The tensile, shear and transverse strengths of this iron, which contained C, 2.47; Si, 1.73; Ni, 1.98, and Cr, 0.176 per cent., well exceeded the best cast free from special elements. It showed, however, a tendency towards microporosity, the presence of which caused a fairly wide dispersion in the tensile results. This iron is practically insensitive to section thickness. It is, however, not free from slight heterogeneity.

Nickel-molybdenum Irons.—(*a*) Irons with 2.3 to 2.4 C, and about 1.5 to 2.0 per cent. Si (*circa* 1.5 per cent. Ni, and 0.5 per cent. Mo). The mechanical properties of these irons are high, but the metal presents a strong tendency to porosity and microporosity, as well as distinct hardness rendering machining difficult. Tensile results showed dispersion due to microporosity. (*b*) Irons with 2.5 to 2.7 per cent. C, and about 1 to 2.3 per cent. Si. The iron with 2.3 per cent. Si, gave an average tensile strength of 46 kgs. per sq. mm. (29 tons per sq. in.), and presented no particular tendency towards porosity, whilst low-silicon irons showed considerable porosity and liability to microporosity. (*c*) Irons with 2.7 to 2.9 per cent. C, and about 1.3 to 2.1 per cent. Si. The casts examined reached or exceeded 40 kgs. per sq. mm. tensile strength.

The highest mechanical properties were obtained with less than 1.7 per cent. Si. The nickel-molybdenum irons appeared to show a tendency to be affected by section thickness, certainly more than the nickel-chrome iron, and above all in the realm of heterogeneity. The tendency towards porosity is a function of the carbon and silicon content, the highest being shown in the case of the lowest C and Si contents.

The chemical composition of the type both well

* FOUNDRY TRADE JOURNAL, pp. 185, 451—vol. 79; p. 31,—vol. 80.

French Foundrymen's Association

suited to the foundry and to yielding higher strength has been fixed at C, 2.7 to 2.9; Si, 1.7 to 1.9; Mn, 0.6 to 0.8; Ni, 1.5 to 1.7 and Mo, 0.5 to 0.6 per cent. Irons of this composition have been made in a 5-ton electric furnace and the test results have confirmed the soundness of the castings as well as the high level of their mechanical properties. It can be stated that the inoculation by calcium silicide produces, even in irons melted in the electric arc furnace, a definitely ameliorative effect on the overall mechanical properties and structure, just as it does in cupola-melted irons which are not subject to superheating, and have no contact with a calcareous slag.

The influence of casting temperature of the metal on the mechanical properties has not yet been established, but it has been noticed that there is increased porosity in test-pieces cast at low temperatures.

The next Paper dealt with the question of ingot moulds for steelworks, and was presented by Mr. Charmeau, of Schneider et Cie, Le Creusot. This will be presented in a future issue of the JOURNAL.

Aero-engine Castings

The next Paper presented was by Mr. René Buquet, of the French ministry of munitions, who reviewed the new requirements necessary for the proper control of foundries making aero-engine castings. Apparently, in January of this year, the Service Technique Aéronautique issued a specification, which divided castings into three classes, the most important being class C. The system imposed for this class involves the submission of one or more sample castings before bulk production can be started. The author deplored the fact that essential types of testing machines were not yet installed in all the foundries.

Dr. Jenicek next presented his Paper on bonds for core sands, and was able to throw some light on the benefits and drawbacks resulting from mixing organic and inorganic materials to form core compounds.

The last Paper at this session was by Professor Girardet, who outlined an electro-chemical theory of the action of the reagents used in metallography of grey irons. The theory is based on personal practice, especially in the making of ingot moulds.

Modernising Foundries

The Saturday morning session opened with the presentation of the American exchange Paper written by Mr. C. W. Schwenn; it dealt with the interesting subject of the modernisation of small and medium-sized foundries with the object of increasing production. A good type of knockout was included in the Paper, which covered the simpler forms of mechanical handling. Next, there was a Paper from Mr. M. Stralenka, of Prague, which outlined the polarographic method of analysis, and this was followed by a useful contribution from Mr. G. Joly, of the Centre Technique, on the "Size and Shape of Cupola Tuyeres." This will be published in abstract in our columns at a later date.

A Paper on accident prevention, by Mr. Coupel du Lude, and one on the technical possibilities of fuel economy in the melting of metals, especially in the cupola, by Mr. J. Bobst, of Lucerne, followed. In it the author suggested that before any investigation was made there should be available a detailed knowledge of the existing plant and its performance. Suggestions for improvements centred around the penetration of the blast to the middle of the cupola, to be associated with the blast pressure and shape of tuyeres and their number, together with the size and shape of the coke. Next, the author suggested the reduction of the well of the cupola to a minimum compatible with the size of the castings to be made and the homogeneity of the charges. Other factors were, proper charging to equalise melting, and the control of the gases to the ratio of $\frac{2}{3}$ of CO_2 to $\frac{1}{3}$ of CO_2. He advocated the selection of scrap so as to give a compact bed imposing maximum resistance to the gases and thus cooling them. A novel suggestion was that of regularity in size and a smooth surface of the coke, so as to offer an easy passage to the gases and reduce their contact with it to the minimum.

Other suggestions made were towards the intensification of the heat exchange between the ascending gases and the descending charge. To this end the upper part of the cupola should be of reduced section, whilst the compactness of charge, already cited, is also important. To retard the early combustion of the coke, the author advocates wetting or coating with lime and air drying before use.

The coke bed must be kept very strictly at 30 in. below the tuyere level [no size of cupola is stipulated. —Ed.]. It must be lit at such a time as to avoid waste through waiting. The author stresses as being important large-sized coke and small-sized scrap and pig. A figure we do not recall ever having been recorded is that the consumption of the bed coke is, during the first hour, double the average, whilst during the tenth hour, one per cent. of the bed charge is consumed.

Amongst indirect factors acting against economy are, sand adhering to pig and scrap, and rusty material. A novel suggestion is the charging of still hot runners and risers [this we consider to be impractical.—Ed.]. In general, this is quite an interesting Paper. The session closed with a formal speech by the chairman.

NOTES FROM THE BRANCHES

WEST RIDING OF YORKSHIRE.—On November 9 the branch visited the works of Thos. Broadbent & Sons, Limited, Huddersfield. Mr. B. Broadbent welcomed the visitors (numbering about 100), who spent the afternoon inspecting the extensively modernised foundries and machine shops. Tea was provided by the company, and Mr. D. W. Hammond, vice-president of the branch, expressed the members' thanks for the opportunity placed at their disposal by the firm for a welcome and instructive visit. Mr. J. Timbrell seconded the proposal. Mr. Illingworth, foundry manager, suitably responded.

THE INFLUENCE OF COBALT AND NICKEL IN VITREOUS ENAMEL GROUND-COATS*

By GORDON C. PRIDDEY†

INTRODUCTION

For well over half a century, cobalt and nickel have held a position unique in the history of vitreous enamelling on iron and steel. The value of these metals has always been recognised in assisting the development of sound adhesion between the enamel coat and the sheet-iron surface, and to-day cobalt and nickel oxides are important constituents in almost all ground coats used in the enamelling of metal surfaces.

The fundamental reason why these metals hold such a pre-eminent position in this important branch of ceramic art does not seem to have been explained to the entire satisfaction of scientific observers of the phenomenon of adhesive power of enamels. From a review of the available literature on this subject, it would appear that there is still a lack of general agreement, between investigators, with regard to the precise function of cobalt and nickel in ground-coats.

In these circumstances, it is believed that in preference to an attempt to introduce new theories, which would only add to the present complexity of the subject, a *résumé* and discussion of the more important recent works will be helpful, in so far as it might elucidate a few facts which could be used to pave the way for better understanding, or even supply some useful material which could form the basis of a new line of approach.

That there is a direct association between the action of cobalt and nickel and the problem of sound adhesion is a fact established beyond doubt, but where is the valid evidence that the influence of these metals is properly understood? It may be that the answer to this question is implied in one or more of the several theories already propounded. However, until the general principles are made clearer and finally agreed upon it is difficult to imagine how the average enamel technologist could follow any of these doctrines, with the belief that by the use of these vital elements or the adjustment of their ratio he could control or improve the adherence properties or the quality of his enamels.

This problem of close and defect-free adherence has been the subject of considerable investigation, and much time has been devoted to the study of agents for promoting adherence. The object of these researches has been to gather sufficient evidence to provide for a satisfactory theory of ground-coat adherence to iron. The result of such experience has been the development of improved methods in enamelling technique and the production of iron and steel stock of superior quality.

The fact that these improvements have taken place, whilst the composition and properties of the ground enamel have remained unchanged, is significant as indicating the complexity of this problem of adhesion. This complexity is due partly to the presence of other constituents, having either beneficial or interfering properties, both in the sheet-iron and ground-coat. There are also complex reactions of cobalt, nickel and iron, some of which are still understood, which may take place at the liquid phase of the enamel. These must also be taken into account.

The presence of these intricate factors would appear, so far, to have prevented investigators from reaching any unanimous line of thought or agreement. This fact is made more remarkable by the lack of support from the scientific experts on vitreous enamelling, which would give predominance to any one particular theory.

Theories of Ground-coat Adherence

When the principal theories are examined, this state of affairs is not surprising, for the difference between them is so great as to render comparison difficult. For example, there are:—

(1) The theory of purely mechanical adherence, effected by enclosing the projections and filling the depressions on the metal surface.

(2) Electrochemical deposition. In this theory it is suggested that cobalt and nickel plate out and adhere to the iron, causing the enamel to become mechanically bonded to the iron surface.

(3) The dendritic theory. This contends that dendrites crystallise from the iron oxide, by reduction, either before or after the solution of iron oxide in the enamel. These dendrites, it is suggested, become attached to the iron base, thus mechanically keying the enamel.

(4) The theory that cobalt and nickel act as oxygen-carriers, conveying atmospheric oxygen to the iron, and producing a film of iron oxide which forms a bond at the interface of enamel and iron.

(5) The theory that iron oxide, formed on the metal surface, enters into solution in the enamel, to form a chemical union bond.

(6) Other theories which are associated with the evolution of reducing gases, hydrogen and carbon monoxide, which, it is suggested, reduce the iron oxide, thus causing the formation of dendrites.

The most valuable of the researches have involved much detailed experimental work, but nevertheless some doubts have managed to creep in. Others are embodied in one way or another in the major works.

The one feature upon which, perhaps, general agreement has been reached is that cobalt and nickel are still essential elements in this process of adherence.

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*A Paper presented to the annual conference of the Institute of Vitreous Enamellers.

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The Influence of Cobalt and Nickel

As the influence of these two metals is the primary subject of this Paper, the Author's remarks will be confined to this aspect, although it is difficult to do this without entering into the very controversial problems associated with the production and enamelling of iron and steel stock.

Of the theories so far described, two only need to be considered in association with the fundamental action of cobalt and nickel. These are based upon: (1) A principle of oxidation created by the presence of cobalt and nickel; and (2) precipitation of the metals, electromechanically or by reduction. Other views are founded on somewhat precarious bases, although it is admitted that certain features of these link up in many ways with this classification.

Mechanism of Bonding

It is established that enamel is held to the iron by the agency of a bond and not merely by gripping or atomic attraction, as in the case of the joining of many other substances. It is also important to remember that this bond is not applied, but is actually formed by a chemical process. It is possible that in the study of bond-formation, investigators have dwelt so much on the higher chemistry and physics of the process that the purely mechanical requirements may have been somewhat overlooked, in which case a few words on this subject may not be out of place.

The simplest ideal form of joining metals would be one in which the bonding material employed has the property of facilitating interfacial penetration. Of this there are numerous examples, the most elementary perhaps being the art of soldering, where the two metals joined are similar in character and alloying properties.

Here there is interpenetration of the bond or solder into both faces of the metal to be joined. The bond itself is of flexible nature; if it were brittle, fracture on impact would be inevitable. When substances of dissimilar character have to be joined, the process becomes more complicated and the properties of the bond could enter the chemical or physical phase or both.

Glass-to-Metal Seals

Such a case of complex adhesion is found in the joining of glass to metal. The simplest forms are the glass-to-metal seals, for example, glass-to-platinum special nickel-iron alloys or gas-free copper. It is true that the relationship of the coefficient of expansion of glass relative to that of metal plays an important part in perfecting these seals, but the point of interest at the moment is the difference in behaviour between gas-free high-conductivity copper and ordinary copper sheet. While the former joins by simple adhesion, there is evidence that liberation of oxygen from ordinary copper sheet results in an imperfect seal.

From this it is at once deduced that the presence of gases in metals could contribute very largely to the successful formation or the failure of the bond between glass or enamel and metals. In the case of enamelling on copper there is evidence that the bond is cuprous oxide and that the enamel is held by the slight solubility of copper oxide in the enamel, and the high solubility of cuprous oxide in the copper base. Such simple conditions do not exist in the case of iron.

Sheet iron is not only more susceptible to corrosion and oxidation than copper, particularly under enamelling conditions; the process of oxidation of the iron is far more complicated. The presence of carbon, oxygen and an abundance of hydrogen, which under enamelling conditions creates disturbances, prevents straight application of a simple cover coat. Even in ground layers it is essential to employ an agent which will arrest or inhibit much of this interference, and/or turn to useful purpose such evolutions or reactions as are favourable to the formation of a satisfactory union between the enamel and the iron surface.

Consideration of Utensils

Involved as this technique of enamelling on iron and steel may be, consideration has also to be given to the effect of the shape of utensils and the after treatment they ultimately have to withstand. In this connection the possibility of rapid and differential temperature changes must be considered and the enamel must also be resistant to reasonable shock and impact. From this it is evident that the type of bond required is one which is flexible or elastic in character, capable of relieving or absorbing stress and strain in the more brittle enamel. It must also possess a graduation of coefficient between those of iron and enamel, which, incidentally, should be as close as possible. Such a bond must also hold the enamel tenaciously to the iron throughout the range of variable conditions which arise in the normal usage of the enamelled ware.

In the intricate process of obtaining this combination of properties the significance of cobalt and nickel is recognised, but their precise influence is not fully agreed upon. Some investigators hold the belief that it is by virtue of the oxidising properties peculiar to these vital elements that good adherence is obtained while others attribute the effect to the relative position of the iron to these two metals in the electromotive series. Without exception, however, all theorists are agreed on one point, *i.e.*, the primary association of the oxides of iron with the principles of adherence. For a full study of this process a knowledge of the nature and formation of these oxides is therefore of vital importance. White[1] has given details of the iron-oxygen system, and Kautz[2] has stressed the importance of this system to enamellers. More recently Wainer and Baldwin[3] have dealt extensively with iron, nickel and oxygen systems, whilst Bernard[4] has studied the influence of cobalt and nickel oxides on the decomposition reactions of iron oxide.

Since so much valuable work has already been done on this subject of iron-oxidation it would be beyond the scope of this Paper to review these systems further. They are, however, applicable to all the theories at present under review.

Effect of Cobalt Nickel and Manganese Oxides on the Transfer of Oxygen to Iron through the Enamel Mass

Working on the theory that a film of iron oxide is exclusively responsible for adherence, Kautz[5] has presented some useful observations on the influence of cobalt and nickel in the formation of this oxide film.

This investigator considers that the oxidation of the metal surface takes place in two stages:—

(1) Primary oxidation, resulting from direct action of atmospheric oxygen upon the metal base, before the enamel frit has sintered or melted together.

(2) Secondary oxidation, which takes place after fusion.

It is in the mechanism of this secondary oxidation that the oxides of cobalt and nickel, contained in the ground coat, come into prominence as oxygen-carriers or oxidising agents.

For the purpose of studying the functions of these oxides in relation to the formation of iron oxide at the interface of the enamel and iron and the adherence of the enamel to the metal base, Kautz prepared five enamelled test sheets on which the ground coats contained (*a*) no oxide addition; (*b*) 0.5 per cent. Co_3O_4; (*c*) 0.5 per cent. NiO; (*d*) 1 per cent. MnO_2; (*e*) 0.5 per cent. Co_3O_4, 0.5 per cent. NiO, 1 per cent. MnO_2.

The prepared sheets were fired under normal time, temperature and furnace conditions and were examined after being submitted to standard physical tests. The results obtained from these investigations are summarised as follows:—

(*a*) *Clear enamel* caused an extremely light film of iron oxide and gave poor adherence to iron.

(*b*) *Addition of* 0.5 *per cent.* Co_3O_4 caused heavy film of iron oxide to form and gave considerably increased adherence.

(*c*) *Addition of* 0.5 *per cent.* NiO caused medium film of iron oxide to form, with moderate adherence.

(*d*) *Addition of* 1.0 *per cent.* MnO_2, as compared with clear enamel, did not cause increased development of iron oxide film nor give increase in adherence.

(*e*) *Addition of mixed oxides* produced a heavy film of iron oxide and gave slightly greater adherence, as compared with that containing cobalt oxide only.

It is deduced from the above results that cobalt oxide greatly aids or accelerates adherence, allowing heavy iron oxide films to form between the enamel and the iron surface and accelerating the penetration of atmospheric oxygen through the molten enamel during firing.

Nickel oxide increased adherence, compared with clear enamel, allowed a medium iron oxide film to develop, and accelerated penetration of atmospheric oxygen, but its action was less effective than that of cobalt oxide. Manganese oxide, hindered adherence, not assisting the formation of iron oxide film or the penetration of oxidation through the enamel mass. There was, however, an increase in the solubility of iron in the enamel.

The result obtained by combination of the three oxides gave a result equal to that obtained by cobalt oxide alone, and in addition there was evidence of better diffusion of iron into the enamel ground-coat.

Kautz concludes from this investigation that the oxides of cobalt and nickel act as oxygen-carriers, assisting the formation of an iron oxide film between the enamel layer and the iron base, which, it is maintained, is essential for sound adherence. The exact composition of the iron oxide bond is not clearly described, neither are any reactions given in support of the evidence offered. If it can be assumed from the previous work of the Author,[6] that the iron oxide-film consists essentially of a mixture of Fe + FeO + Fe_3O_4, formed by the decomposition of FeO, then the action of cobalt and nickel, as already indicated, must be one of speeding up the rate of oxygen-diffusion through the enamel mass in some way to assist in the formation of FeO, for it is made clear that the original iron oxide film formed enters into solution in the enamel and the adhering bond is formed chiefly during the second oxidation.

Cobalt, Iron and Nickel Oxides in Relation to the Metallic-phase Formation

In contrast with this view, Dietzel[7] has presented a theory of adherence based on the graduation of the coefficient of thermal expansion of the ground-coat, resulting from a solution of iron-oxide in the enamel. Adherence-promoting oxides do not participate in the earlier stages of the reaction, which result in the formation of ferrous oxides according to the reaction $Fe_3O_4 + Fe \rightleftharpoons 4FeO$. On cooling, decomposition of the FeO begins at 575 deg. C. according to the reverse reaction $4FeO \rightarrow Fe + Fe_3O_4$, but it is before this stage is reached that cobalt and nickel become technically important.

It is asserted that the most satisfactory adherence-promoting oxides are those of the metals more noble than iron and therefore capable of being reduced by iron into the elements, thus Fe + CoO/NiO → FeO + Co/Ni. During the precipitation of these metals on the iron, local currents appear which produce a strong corrosion of the iron surface at high temperatures. The enamel fills up the cavities and adheres, presumably, on the cobalt- or nickel-"plated" iron.

It would appear from this work that oxidation of the iron is the only reaction responsibile for effective adherence. First a film of Fe_3O_4 is formed, which is soluble in the ground-coat. At increasing temperature FeO begins to form, and this scale is also taken into solution on the fusion of the enamel. The ferric oxide still existing reacts with the iron surface to form FeO and thus, at a critical temperature, the FeO decomposes into Fe_3O_4 + Fe the enamel becomes saturated with Fe_3O_4, and the latter compound begins to separate as minute crystals. At this critical period the CoO reacts with the free iron, yielding a bond of complex composition, while the iron oxides retained in solution in the enamel increase the co-efficient of expansion, so that it is practically identical with that of the metal.

In a later treatise on the electrolytic reactions in vitreous enamels, Staley[8] tends to support the view

The Influence of Cobalt and Nickel

that metal-precipitation does take place. It was observed that in experiments based upon various metals contained in simple glass, using cobalt, the blue colour disappears and the greenish colour of ferrous iron grows in intensity, leading to the conclusion that cobalt oxide either changes or is completely drawn out of solution, iron oxide taking its place. Microscopic examination of the iron surface, after such tests, reveals the presence of metal dendrites, which it is presumed bond the enamel mechanically to the metal base.

The conclusions arrived at from this work are that all metals between iron and copper in the electromotive series are plated out during the first process by the electrolytic action of the iron base. It is contended that the deposition of cobalt and nickel promote adhesion, because these metals adhere tenaciously to the iron base, whilst enamel does not. The thermal expansion of these metals lies between those of enamel and iron and it is considered that this acts in a compensating manner.

The theory of precipitation of metals and the formation of plates or dendrites is by no means new. As far back as 1932 King[9] observed the presence of so-called dendrites, and in subsequent years King and his co-workers have contributed much to establish proof that ground-coats are mechanically held by the existence of dendrites projecting from the metal surface. These dendrites are stated to consist of alpha iron, but until recently their formation has not been closely associated with the action of cobalt and nickel.

Electrical Resistance of Ground-coats

King[10] has sought to establish the rôle of cobalt oxide in metal-precipitation by accurately measuring the electrical resistance of ground-coats when fired between two enamelling-iron test-pieces. Samples of standard ground-coats were used for testing, both free from addition of promoting agent and containing 1.5 per cent. Co_2O_4 and the equivalent of NiO. Specially designed apparatus was used and resistance was measured by means of a Wheatstone bridge. Comprehensive details are given of the results of these tests, which have led to the following conclusions: (1) The electrical resistance of cobalt-bearing enamels decreased with decreasing temperature, reaching very low value on cooling; and (2) enamels which do not contain cobalt show increasing resistance on cooling and reach high values at normal temperature.

The explanation of this difference lies in the fact that metal is precipitated in the ground-coats containing cobalt, and that there must be intimate contact between precipitated metal and the metal base. It has been concluded from these tests that the reactions between cobalt oxide and iron oxides, already established by Bernard[4] take place, at least qualitatively, at the ground-coat iron interface.

Bernard[4] has shown that FeO formed at high temperature decomposes according to the reaction $4FeO \rightarrow Fe_3O_4 + Fe$; the temperature of such decomposition is 575 deg. C. At elevated temperatures CoO and NiO both exist in equilibrium with the FeO. These oxides inter-react and decompose on cooling, forming Fe_3O_4 + metal according to complete reaction $3FeO + CoO/NiO \rightarrow Fe_3O_4 + Co/Ni$.

So far, reference has been made to the fundamentals of the most favoured theories on the functions of cobalt and nickel on the adherence of ground-coats to iron, as applied to standard enamelling iron and steel stock. There are some points in common, yet, in fact, in the application there seems to be a lack of sufficiently convincing proof of the completeness of any particular theory, which is so essential for general acceptance between investigators.

Such conditions are frequently found in complicated problems, but a clearer understanding of basic principles is necessary before it can be said that the valuable properties of these metals are being used to the best advantage. Without such full knowledge, it may well be queried whether cobalt and nickel are the best metals to use for the purpose, or if the present method of application is extracting the highest efficiency which they are capable of giving.

What is of vital importance to the enameller is the eradication of the causes of failure, and of the defects which are contributory causes of bad adhesion. Many defects have been under investigation for years, without successful elimination, and the use of ground-layers is, in a measure, a means of absorbing or balancing these irregularities before the application of the cover-coat.

Functions of Nickel and Iron in the Interfacial Application of Nickel by Means of the Nickel-flash Process

It is known that cobalt and nickel in ground-layers inhibit excessive oxidation of the iron, preventing defects due to this cause from appearing in the cover-coat, and this led to the introduction of the process now known as the "Nickel Dip." In addition to the control of conditions which lead to such defects as copperhead and fishscale, the flash of nickel on the surface of the iron materially aids the development of adherence.

An examination of the principles involved in the successful application of single-coat enamels on iron, through the medium of the nickel-flash, is comprehensively dealt with by Wainer and Baldwin.[3] The fact that sound adhesion can be obtained by the agency of the nickel deposit so formed, simplifies the study of its influence, because many of the complex factors which have confronted past workers have been eliminated. Apart from a review of this work being of considerable general interest, it may, in discussion, contribute some factual support to the excellent, although controversial, works already described.

A film of nickel is deposited on the iron sheet electrochemically, by immersion in the required solution.[13-21] The process is essentially one of corrosion, whereby the iron passes into solution, displacing its equivalent of nickel. The constitution of this deposit is variable, but appears to be chiefly metallic nickel with small amounts of nickel oxide and nickel hydrate. Evidence is given that the nickel coating regulates the oxidation of the iron surface at high temperatures, and from tests

carried out on the oxidation of nickel-iron alloy, there is also evidence that nickel has a profound effect upon the nature of the iron oxide formed.

Samples of iron, nickel-flashed iron and nickel alloy were enamelled, with and without pre-oxidation, and the following results were obtained:—

Without Pre-oxidation—

(1) Iron.	No adherence.
(2) Nickel alloy.	No adherence.
(3) Nickel-flashed iron.	Good adherence.
With Pre-oxidation—	
(4) Iron.	No adherence.
(5) Nickel alloy.	Good adherence.
(6) Nickel-flashed iron.	No adherence.
With Bright Annealing—	
(7) Nickel-flashed iron.	No adherence.

The mechanism of the oxides formed by pre-oxidation of nickel alloy was examined by electron diffraction. The result indicates that there is a mixture of an oxide and a metallic phase in the surface layers, and from reasoning given, this appears to be Fe-Ni alloy or possibly Ni, with Fe_3O_4. The metallic constituent was a characteristic of the scale.

A similar examination was made of scale formed between iron and non-adhering enamel. No metallic phase was observed and the oxide phase appeared to be Fe_3O_4.

Abundant evidence is offered by references to systems established by investigators who have studied the mechanisms of iron and iron-nickel oxidation. These investigations provide some pertinent facts which are, in a way, interrelated with the process of adhesion as applied to ground-coat enamels.

Oxidising of Iron

Dealing with oxidising of iron (samples 1 and 4 above), iron oxidises at high temperature producing a scale which varies continually between Fe_2O_3 and FeO, and FeO reacts with higher oxides of iron to form an oxide or a mixture of oxides having higher oxygen content than FeO.[11] On this basis, pre-oxidation of iron without a controlling influence would yield a non-adhering metal-free scale consisting of Fe_2O_3 or Fe_3O_4 in contact with Fe_3O_4, which alone cannot be the adherence-promoting oxide.

It is evident that one of the functions of nickel-flashing is to prevent or restrict the formation of Fe_2O_3 and possibly Fe_3O_4 by taking charge of part of the available oxygen, not only in the heating up period, but also at the enamelling temperature.

With plain enamel fused on nickel-iron (sample No. 2), no adherence resulted, little oxide was formed at the interface and the enamel left the metal clean at the face. Not until the metal was pre-oxidised (sample No. 5) was adherence obtained; hence metallic iron cannot be the developing agent without the presence of an oxide of iron.

Low nickel steels are oxidised by heat, first to FeO and NiO; by contact with metallic iron, NiO is reduced to nickel, releasing oxygen for further oxidation of the iron.[12] This is proved by examination of the scale, which at the outer surface is mainly iron oxide, while the inner surface close to the metal is rich in nickel. It is also shown[11] that NiO cannot exist in equilibrium with iron oxide containing more than 72 per cent. iron at medium temperatures, and less than 77 per cent. in contact with iron at high temperatures. Under these conditions nickel oxide is reduced to metallic nickel.

From this it is evident that with nickel-iron and nickel-flashed iron, the oxidation process at high temperatures partly explains the presence of metallic nickel by the inability of NiO to exist in contact with FeO without becoming reduced to nickel.

It therefore appears that in the enamelling cycle, nickel-iron and nickel-flashed iron first oxidise to NiO and higher oxides of iron. The conditions remain stable up to about 570 to 650 deg. C. owing to the stabilising presence of the nickel. At this point the enamel begins to fuse, shutting off external oxidation, and the Bernard reaction begins to reverse itself thus: $Fe + Fe_3O_4 \rightarrow 4FeO$. Near the complete reaction, NiO will dissociate, releasing oxygen for further oxidation of the base iron, and on cooling again according to the reversed reaction, $Fe_3O_4 + Fe$ will be formed, and the nickel will be present as such or in solid solution with the precipitated iron. It is stated that the formation of the FeO is influenced by the presence of nickel trying to oxidise, and the reducing conditions of the NiO-dissociation, thus stabilising the formation of higher oxides of iron.

There is evidence that nickel exerts a controlling influence on the nature of the iron oxides formed, and ensures the formation of FeO at high temperatures, but it is not safe to assume that nickel itself is involved in the process of adherence.

Controlling Factors in Development

Further references to the process of adherence indicate that the important controlling factors in development are: (1) Concentration and nature of the oxidising and reducing agents; (2) some mechanism for controlling the degree and nature of oxidation. Adherence materials may be supplied in one of three ways:—

(*a*) Through the composition of the metal (Ni-Fe alloy;

(*b*) through the use of an added surface (nickel-flashing);

(*c*) through the enamel composition (NiO-Co_3O_4).

The conclusions add "that the adherence-promoting oxide for sheet iron appears to be FeO at enamelling temperatures. FeO is formed under certain equilibrium conditions which are obtained through the presence or formation of a material known as an adherence promoter, which acts as a stabiliser for, and the continued development of, FeO.

"The bond at normal temperature consists of a mixture of stabiliser material, probably metal, metallic iron and Fe_3O_4, the last two the result of decomposition of FeO and cooling; an alloy of Fe and stabilising metal may possibly form."

The Influence of Cobalt and Nickel

Summary and Discussion

Scientific and practical experience has proved beyond doubt that cobalt and nickel are indispensable metals in the process of enamel-to-iron adherence; there is certainly no evidence offered to the contrary. On studying the vast amount of literature on this subject, one is convinced that the average reader is merely confronted with a mass of detail and divergent opinion, and that the precise understanding of the influence and value of these vital elements is lost in obscurity. It is, therefore, hoped that by a discussion of the works so far described, a few essential facts can be isolated, and when reviewed in a collective sense, they can be made to yield to scientific reasoning.

Dealing with the oxygen-carrier theory, it must first be said that the work of Kautz is considered a valuable effort because it offers two or three clues, although they may prove adverse to the theory originally presented. In this respect, it is not so much the desire to be critical as it is to be helpful.

Of the metals in question, only cobalt, manganese and iron are recognised by industrial science as oxygen-carriers. Cobalt is of the first importance, being closely followed by manganese, and iron later in the series. Nickel, on the other hand, is not an oxygen-carrier in the same sense: the chemistry of its oxides is different, and therefore it cannot function in the same manner as cobalt or manganese.

Reference is frequently made to such compounds as Ni_2O_3 and Ni_3O_4, but as the possible existence of the former is debatable, and the latter does not survive dull red heat, these can be ruled out of discussion. The only oxide of nickel of importance to the enameller is NiO, and for the purpose of ground-layers, it does not matter whether it is black or green in colour.

Unlike nickel, cobalt forms three oxides, namely, CoO, Co_3O_4 and Co_2O_3. The latter compares with Ni_2O_3 in so far as it decomposes below red heat, which leaves only CoO and Co_3O_4 of value to the enameller.

Oxygen Pressure

When considering the possibility of Co_3O_4 acting as oxygen-carrier at enamelling temperatures, it is important to observe the oxygen pressure of this oxide, which is given by Moissan as follows:—

Temperature (deg. C.) ...	800	850	900	910	975
Oxygen pressure m/m...	10	28	144	183	765

It follows from this that Co_3O_4 would quickly reduce to CoO particularly in the presence of iron, and remain so reduced around the temperature of fusion of the enamel.

Kautz found that NiO gave good adherence only slightly inferior to that obtained with Co_3O_4, and much in advance of that obtained with plain enamel. Enamel containing manganese failed to give effective adherence, and only compared with plain enamel in this quality. These observations are important because (1) Manganese, a known oxygen-carrier, gave no adherence; and (2) nickel, not an oxygen-carrier, gave good adherence.

Another striking example in the difference in behaviour of manganese, when compared with cobalt and nickel, is given by King and other workers, who found nickel and cobalt metal at the enamel-iron interface, when examining enamels containing these metals. This metallic phase, consisting of Fe-Ni-Co, was confirmed by electron diffraction. When manganese was used either alone or with cobalt and nickel no metallic manganese was found to be present at the interface.

Heats of Formation

So far no explanation has been given for these differences, and it is possible that a study of the heats of formation of the metals in question might throw some light on this.

It would be expected that those oxides which have a low heat of formation would give up their oxygen to a metal whose oxide has a higher heat of formation. The heats of formation of the oxides associated with this problem are as follows:—

Oxides	CoO	NiO	FeO	MnO	MnO_2
Kilo cals/gm. mol. ...	57.7	57.9	65.7	97.8	126

It is apparent from the heats of formation that CoO and NiO would be reduced to the metallic condition in the presence of iron at the firing temperature, the products being nickel and/or cobalt metal plus FeO.

In the case of manganese oxide, however, the heat of formation is so considerably more than that of FeO that it would not be reduced, as in the case of CoO/NiO; in fact, on the contrary, manganese would reduce the FeO.

The above facts are in harmony with Dietzel's views, which rely upon the above-mentioned Bernard reaction, which indicates that CoO/NiO are, in fact, reduced to metal by iron, thus resulting in FeO entering the enamel, leaving metallic Co/Ni as a bonding agent at the interface. For convenience the Bernard reaction is again quoted as $7FeO+CoO \rightarrow 2Fe_3O_4+Co+Fe$. The heat of formation would be 517.6 kilo cals/gm. mol. to the left, and 541.6 to the right leaving the balance of power in favour of the iron.

A further interesting contribution has been made by Wainer and Baldwin. This work, although primarily associated with nickel-flashing, is full of valuable detail, with numerous references to other scientific workers, both in support of the Bernard reaction and the theories in connection with the oxidation of nickel and iron.

In view of the success of nickel-flashing and the recognised superiority of cobalt over nickel in promoting adherence, it would be of exceptional interest to know, if it were possible, how cobalt-flashing would behave. One might expect the most remarkable results.

(*Continued on page* 271.)

GASEOUS MALLEABLISING

The following is the joint discussion of "Notes on the Process of Gaseous Malleablising with Especial Reference to the Use of Steam," by Mr. D. M. Dovey, and "The Annealing Rate of Gaseous Malleablising," by Mr. I. Jenkins and Mr. D. M. Dovey. Both Papers were read before the annual conference of the Institute of British Foundrymen, at Birmingham, in June of this year. "Notes on the Process of Gaseous Malleablising with Especial Reference to the Use of Steam," appeared in the FOUNDRY TRADE JOURNAL *for August 1. "The Annealing Rate of Gaseous Malleablising," was published in our issue of September 19.*

DISCUSSION

MR. A. G. E. ROBIETTE, M.Sc., said he was very interested in Mr. Dovey's Paper on the use of steam for gaseous malleablising, as he considered this some years ago and rejected it on the grounds that it would be far more uneconomical than the use of air. When one oxidised carbon with steam there was an endothermic or heat-absorbing reaction. Two reactions were involved:—

$$C + H_2O \rightarrow CO + H_2 - \text{Heat},$$

then

$$CO + H_2O \rightarrow CO_2 + H_2 - \text{Heat},$$

and both these reactions proceeded to give the required CO/CO_2 ratio, whilst with air there was the exothermic reaction of the oxidation of carbon:—

$$C + O_2 \rightarrow CO_2 + \text{Heat}.$$

It was easy to calculate that (after making allowance for amount of N heated in the air injected into the furnace) to remove say 60 lb. of carbon from one ton of whiteheart malleable iron one would require about 180 to 200 k.w.h. of electricity to decompose the steam, and with power at 0.75d. per unit, this would cost about 11s. 4d. to 12s. 6d. extra per ton of iron castings annealed as compared with the process of using air which he described a year ago. If on to that were added about 1s. for the cost of producing the 180 to 200 lb. of steam required, it gave a total additional cost of about 13s. per ton with, as far as he could see, no attendant advantage.

Additions to Carbon Dioxide

Then at the top of page 2 of the preprint, Mr. Dovey made, he thought, a rather misleading implication. He said that if air were to be added, the CO_2 concentration would be maintained, but that if steam were added both H_2O and CO_2 concentrations would be maintained. He thereby implied that there was some advantage to be gained by so doing, but Mr. Robiette thought the Author would admit that CO_2 would decarburise just as quickly as H_2O. The Author then stated that if there were a gas with 40 per cent. of decarburants there would be four times the decarburising power of a gas containing only 10 per cent. of decarburants. He omitted to add, however, that providing there was an adequate rate of circulation one would decarburise no faster with a gas containing 40 per cent. decarburants than with a gas containing 10 per cent. The all-important fact was that the rate of annealing of malleable iron was limited only by the rate at which carbon diffused to the surface providing always that sufficient gas was available with the correct CO/CO_2 or H_2/H_2O ratio irrespective of actual composition. The Paper by Mr. Dovey and Mr. Jenkins made a reference to a statement by the speaker which they said might be misleading. Mr. Robiette pointed out that according to the diffusion law the depth of decarburisation was proportional to the $\sqrt{t}$, and he showed that this could be used as a practical guide on a comparative basis. He (the speaker) said that if it took 10 hrs. to decarburise a casting ¼ in. thick, then it would take about 40 hrs. to decarburise one ½ in. thick to about the same extent. He had further showed, by Fig. 3 in his Paper, that this was borne out by experiments made on hundreds of castings.

Difference in Results

The results which he obtained were in disagreement with the conclusions of Mr. Dovey and Mr. Jenkins as their curves showed an almost straight line elimination of carbon. He thought, however, their conclusions were based upon too narrow a premise, as they had taken only a single composition, and he also felt that their results should be checked by carbon determinations obtained by drilling right through flat samples, since it was known that under certain conditions other elements were removed from ferrous alloys in reducing atmospheres. He was wondering whether this factor might have caused the discrepancy between the Authors' results and his own.

MR. DOVEY, replying to Mr. Robiette, agreed with his statement that the use of steam necessitated an increase in the amount of heat required per ton of castings treated; however, a considerable percentage of this difference could be regained by burning the exit gases in a suitable heat-exchanger. When the investigation was commenced, they realised that the castings were of a special nature; they therefore used steam.

If they considered that the air process should be used in the more general type of malleable iron annealing—a process, by the way, which was used and described some 30 years ago—they would be only too happy to use it.

Diffusivity Factor

MR. JENKINS said that with regard to the application of diffusivity data it could not be applied as a direct or a square root function of the time, since the rate of diffusion depended to such a large extent upon the constitutional changes which take place in the iron during annealing. On thin castings, for example, complete decarburisation could be obtained without graphitisation, and the square root relationship would hold very well, but with increasing thickness and time of anneal there was an increasing departure from this parabolic relationship. In their investigations the indications were that the rate of solution of cementite

was greater than that of graphite, and in a graphitised iron the rate at which carbon is supplied to the surface is correspondingly slower. With regard to the limitations of the equation, he thought that he had indicated when introducing the Paper that this was fully appreciated by the Authors, but they had put it forward in the hope that it might form a useful basis for future work in this connection.

Cementite Solution and Iron Sulphide

MR. H. MORROGH said the Paper was timely in that it meant that problems relating to gaseous decarburisation were being tackled and investigation kept on the move. With regard to the statement on page 4 of the preprint, beginning, "In high sulphur irons it is generally accepted that the solution of primary cementite during decarburisation is retarded by a film of iron sulphide," it was a pity no references were given. He disputed the statement that this theory was generally accepted. He had never seen any evidence to support it; neither was he convinced that in micrograph A there were any small graphite nuclei. Graphite ought always to be positively identified. In both annealing in ore and in gaseous atmospheres he had not been able to confirm that graphite dissolved faster than cementite and a supposition of this kind contradicted the most elementary laws of equilibrium. He wished to draw attention to the theory tentatively put forward by Schwartz that austenite in equilibrium with cementite may be different from austenite in equilibrium with the graphite phases. If this were true then the rate of diffusion of carbon through these two austenites may be different. It was well known that an iron which graphitised rapidly gave poorly decarburised material, and irons which graphitised slowly gave well decarburised material.

Schwartz Theory of Austenite

MR. JENKINS replied that the Authors stated that "the solution of primary cementite during decarburisation is retarded by a film of iron sulphide" because they had the impression from the literature and from contacts with foundrymen that that was the most generally accepted theory. This theory was also put forward by Schwartz in the Symposium on Graphitisation by the American Foundrymen's Association. There were small nucleii present in micrograph A, Fig. 1. and from careful examination they did appear to be graphite. In spite of Mr. Morrogh's remarks the Authors still considered that there might be some difference in the relative rates of solution of graphite and of cementite. In respect to the theory of Schwartz as to the possibility of a different atomic arrangement for austentite in equilibrium with cementite, to that in equilibrium with graphite, it was a very attractive theory, but one which they felt on fundamental grounds was hardly possible. Even if it were possible they failed to see why the distribution of carbon in the lattice should have any marked effect on the rate of diffusion of carbon.

Graphite Incubation

MR. A. E. PEACE said he noticed that the curves dealing with residual carbon went down from 2 to 1¼ per cent. He wanted to know how the carbon determinations were made. Had the Authors had any case of a ½-in. section where there was a residual content approaching 2 per cent. in the centre of the section. Earlier in the Paper it was suggested that the carbon gradient was almost a linear function of the thickness. He thought that only applied with certain qualifications, since carbon gradient curves for all but the thinnest sections show a step at 10 to 20 thousandths of an inch from the surface. Regarding the film of sulphide, had the Authors identified such a film round the cementite or did they think it could not be recognised due to inadequate metallographical technique. He would also like to learn if they held the view that cementite must dissolve in the austenite before dissociation. Were they aware of the theory of a graphite incubation period put forward by German and American workers to explain the early stages of graphitisation, when the rate was appreciably lower than later, when the process was controlled by migration.

MR. JENKINS replied that the carbon determination and figures quoted were based on loss in weight measurements and not on actual analysis. They had seen, under the microscope, sections ½ in. thick in which the residual carbon content at the centre of the casting approached 2 per cent., but this was only after a very short annealing time. With regard to the carbon gradient being a linear function of the thickness, they agreed that this did not always apply. The step in carbon concentration referred to is probably due to the uniform recession of the primary cementite away from the surface, as the decarburisation and resulting carbon diffusion to the surface proceeds. One would therefore approximate more to a linear relationship after all the primary cementite had been removed. The Authors had not identified a sulphide film around the primary cementite, and considered it doubtful whether present metallographic technique could do so, if it were present. With regard to the nature of the graphitisation process, they had never yet seen any indication that cementite dissociated directly into iron and graphite, but the absence of such evidence did not rule out the probability of it doing so. In fact, Wells, in a Paper published in America just before the war, reported that direct dissociation does take place, and supported this with metallographic evidence. They had certainly come across the initial incubation period during which the rate of graphitisation appeared to be very much slower than later in the anneal. They would not rule out the probability of graphitisation during incubation, since the stage at which the first small graphite nuclei begin to form is naturally very difficult to determine.

INFLUENCE OF COBALT AND NICKEL

(*Continued from page* 268.)

Reverting to the properties of Co_3O_4 and NiO, which are the oxides regularly used in ground-coat enamels, it seems strange there should be a difference in the comparative values of these oxides, but it does appear from general usage and experience that Co_3O_4 is preferred to NiO, although after reduction to CoO, which is isevitable in the firing cycle, it does not necessarily possess any specific superiority over NiO. The extra oxygen could give a slight advantage in the early stages of iron oxidation, or it may be that CoO is more stable with FeO at high temperatures, which is not the case with NiO. However, there is no evidence in literature to show that this difference has been studied.

Conclusions

Whatever may be the merits of the various theories concerning the influence of cobalt and nickel in ground-coats, the undeniable fact is that these metals do promote adherence.

It is exceedingly unlikely that they would do this if they were wholly retained by the enamel. It might, therefore, be inferred, on purely mechanical grounds, that they must be functioning at the interface. There seems to be general agreement on this point, but without any scientific explanation it has been rendered difficult to establish this point, owing to the inert behaviour of manganese. If, however, we accept the heat of formation theory put forward above, then the unique advantages of cobalt and nickel in promoting adherence are established on a physical and chemical basis.

Acknowledgments

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DETERMINING MOISTURE CONTENT OF SAND

(*Continued from page* 260.)

moisture already in the sand. This latter can be brought about by manually varying the position of the counterbalance weights on the doors of the box as the recorded moisture content varies, this being facilitated by calibrating a rod along which the counterbalance weight can move. Fig. 5 gives an outline of the principle involved. Arrangements have been made with a firm of instrument makers for the construction of the simpler form of sand testing unit, described in this article.

Acknowledgments

The Authors wish to thank Mr. W. H. Tait, technical director of the Glacier Metal Company, for his interest in this work and for his suggestions and help in its development.

NEW CATALOGUE

Non-ferrous Alloys. The Eyre Smelting Company, Limited, of Tandem Works, London, S.W.19, have sent us a loose-leaf binder containing their specifications for bearing alloys covering a wide range of uses, and ancillary products such as fluxes; pattern metals; gunmetals, and phosphor-bronze.

Additionally, they have published a size and weight chart for phosphor-bronze and gunmetal rods. These extremely useful publications are available to our readers on writing to the address given above.

A NOTE ON RISERS

By "CORONER"

Risers fulfil a number of functions in a mould, depending on the nature of the metal cast. For some castings in certain types of grey iron, risers are used simply as an indicator when the mould is full, and to enable the flowing through of a quantity of metal to ensure that any untrapped gas is driven off.

For high-duty iron risers are often necessary to feed the casting, somewhat similar to steelfoundry practice. Occasionally waster castings can be traced to the use of inadequate risers, and it is essential for sound castings that risers of correct shape be used, and suitably positioned.

A particular waster once encountered by the writer, was one in which a large shrinkage cavity was found at the junction of the riser with the casting. The peculiar feature of the defect was that it was not over the whole surface but at one end, as A, in Fig. 1. This job was cast in the position shown, and a self-feeding riser had been used on the boss, but unfortunately the moulder did not remember that the virtue of this type of riser lies in its gravity feed. In the case under review the riser had been placed on at right angles to the boss and the job cast with the joint of the mould level—as Fig. 1. Consequently there was no feeding action whatever at one end, resulting in the shrinkage cavity which scrapped the casting.

The remedy, and the practice which should always be adopted, is to cast the mould with the riser in the vertical position, even if it is necessary to tilt the mould, as Fig. 2, to accomplish it. This is also true of jobs where moulding box bars sometimes interfere with the placing of the riser in the vertical position. Letting it lie to one side to avoid the bar may be satisfactory for grey iron work, when the riser is only used to flow the metal through the mould, but for high-duty iron, where the riser has to supply feed metal, this must be placed upright, even if it necessitates the breaking out of a box bar to accommodate it.

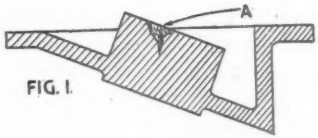


FIG. 1.

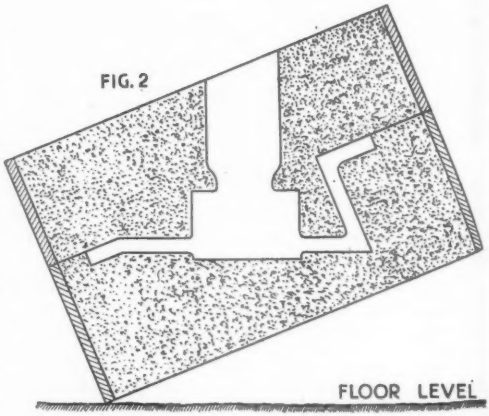


FIG. 2

CO-OPERATION IN REFRACTORIES RESEARCH

DR. REES' INAUGURAL ADDRESS

A summary of Dr. W. J. Rees' address to an inaugural meeting of the Refractories group of the Sheffield Metallurgical Association, held at Sheffield on November 1, is given below. He was speaking on the subject of "Co-operation in Refractories Research."

The formation of the group is, of itself, an indication of the desire for the development of a fully co-operative spirit in refractories research and development. As examples of the progress accruing from co-operative work, reference was made to the activities of the Open-hearth Refractories Joint Panel, and its committees and sub-committees (with special mention of development work of the Basic Bricks Committee); the research committee of the Iron and Steel Institute and their lineal successors, the British Iron and Steel Research Association (particular reference was made to the wartime work of the Moulding Materials Committee and the continuing investigation of converter linings, by the Converter Refractories Sub-committee); the co-operation between the British Refractories Research Association, other research laboratories (including those of Sheffield and Leeds Universities), and industry, has been productive of definite advances in the provision and utilisation of refractories.

Attention was directed to the advantages which would result from a periodic exchange of personnel between research laboratories and works laboratories. The need for such extended liaison as a means of reducing the time-lag between the results of research and their industrial application was emphasised. The following were suggested as fields of co-operation for the Group:—The discussion of fundamental and practical fields to which research should be directed; the discussion of researches in progress (possibly prior to the preparation of a Paper for publication); and the formation of a small sub-group to study published researches in divisions of the general field of refractories, this sub-group would present a short report at meetings of the whole Group. The hope was expressed that the Group would not develop simply into a society for the reading and discussion of Papers, but would give major attention to the stimulation of short contributions and free unreported discussions by the younger members.

DOUBTFUL SECURITY

By "ONLOOKER"

Changes are notoriously difficult and even dangerous on occasions, which, owing to the uncertainty prevailing and the fears of what lies ahead, create suspicion, unrest, and even resentment among a great many people. In the early stages of the war, before the trade settled down to what was to be its wartime set-up, there was a good deal of apprehension about which way we were heading, and it was not until the prices had been revised in December, 1939, that confidence began to be restored. Naturally, people were not quite sure of how things were going to work out in the new and strange experience that lay ahead of them, and they were doubtful about how the Government's intervention would work in practice. As the months went by the wartime pattern began to emerge, and it was not long before manufacturers, and all connected with the trade, settled down to a state of affairs in which the hurly-burly of the metal markets had no part. Fluctuations in the quotations were a thing of the past, and stability spread its soothing influence over the whole pattern of the non-ferrous metal situation. It was not until half-way through 1945 that an adjustment in prices was made (apart from an upward revision of £25 in tin, which was largely a matter of adjustment), and only lead and zinc were affected. By the end of that year, however, it was obvious that the lead position was dangerous, and that something would have to be done about copper.

A Courageous Decision

Looking back one can see that the real end of all chance of keeping quotations on an even keel came when the Government abandoned the practice of long term contracts in favour of living on the ample stocks held in this country pending a re-entry into the market after a break in values due to the aftermath of the war. It was a courageous decision, for in January, 1945, the fighting was not by any means over. However, there had been a cut back in demand in connection with munitions, and the Government were not alone in believing that prices might well ease on the conclusion of the war. Unfortunately, things did not turn out that way, for as everyone knows there have been all sorts of upsets to production, and demand has been in excess of supply. By the time the Ministry of Supply had made up their mind that further purchases were necessary, the situation had altered radically, for the price graph had taken a decided upswing, and producers were adopting an independent attitude. As a result this has led to the longest and strongest sellers' market in metals we have ever seen, and the end is not yet. Amidst this welter of demand probably the most embarrassed people are those responsible for keeping this country going in non-ferrous metals. Long since, they must have abandoned all hope of procuring supplies at reasonable prices, and it is possible that they would be glad to be assured of adequate tonnage over the next 12 months at almost any figure. The producers have no particular cause for worry; they are, as a matter of fact, doing very well in spite of greatly increased costs of production. The fabricators, of course, are on velvet, at present at any rate, for the Ministry shoulder the burden of keeping them supplied, and the rising market provides the opportunity to secure some useful additional profits. On the selling side of their business the problem is how to avoid taking orders and further increasing an already "outsize" balance on hand.

Those Difficult Days

In the circumstances it is not surprising that the old difficult days, when every mill had to make sure of raw material by its own exertions, seem a long way off. Moreover, there was the nagging worry of having to contend with variations in value due to the fact that prices were determined, not by decree as to-day, but through the operation of the laws of supply and demand. This meant that values could and did go down as well as up, and it was therefore possible to lose money if metal were held at risk. Since September, 1939, the users of copper in this country have not known a day's anxiety on the score of possible losses from a declining price. They have not even envisaged (at any rate very few of them) the chance of such a thing happening, for after a spell of six years of fixed values, and nearly 12 months of rising prices, it is not easy to imagine a state of affairs in which quotations decline. Nevertheless if we are to judge from the way in which some commodities are behaving (cotton, mercury and platinum come to mind), the time will come when, perhaps from a higher level than that at which they at present stand, the non-ferrous metals will "boil over" and take a downward plunge. During the past year the Ministry have found out all about being under-bought on a sellers' market, but it will be very strange if the consumers in their turn do not have to face up to the implications contained in the two words "over bought." Strong as the price structure appears to be at the moment, there cannot be much doubt that we have already seen the first signs of the ending of the sellers' market and the change of direction in the commodity price curve. The writing is on the wall, and it would be wise for all concerned to take stock of a situation which contains the germs of possible loss and disaster. When the turn does come it may well be rapid, and it is worth remembering that all markets look strongest at the top.

MOTOR CAR PRODUCTION in the United States registered a moderate drop in September, halting the industry's previous uphill climb toward pre-war production levels. General shortages in sheet steel, pig-iron, copper and lead largely accounted for the decline. The lorry output totalled 92,044 units compared with 105,506 in August. Passenger car output held at 239,140 units, a decrease of only 2,162 from the previous month. With only 20 working days in September compared with 22 in August, however, the daily rate of production showed a gain. The September output was at the daily unit rate of 11,957 as against 10,068 in August.

NEWS IN BRIEF

THE BIRTLEY COMPANY, LIMITED, Birtley, Co. Durham, are installing plant for the production of light machine parts for tractors and mining equipment. Machinery is also being installed for making refrigerators.

SIR CHARLES J. BARTLETT, managing director of Vauxhall Motors, Limited, Luton, has told the employees that the company's scheduled output of 80,000 vehicles for next year will have to be cut to 55,000 owing to the shortage of steel.

GROSVENOR UTILITIES, LIMITED, and B. B. KENT, LIMITED, vitreous enamellers and tool makers, announce that their offices at Haymarket, London, W.1, have been transferred to their Ajax Works, Ming Street, London, E.14.

CONSTRUCTION OF 100,000 factory-built aluminium houses in America in 1947 by private industry is being planned to speed up the ex-Servicemen's emergency housing programme. At least five converted aircraft factories will participate in the programme, and are set to start assembly-line production of aluminium houses in the near future.

LINOTYPE & MACHINERY, LIMITED, Altrincham, Ches, announce that, having been released from national work, their works are now actively engaged on a large number of orders received from all parts of the world. A new factory is being erected alongside their existing works. The assets and liabilities of the French subsidiary have now been taken over by the parent company.

SPEAKING AT THE annual meeting of Allied Ironfounders (Ireland), Limited, Mr. R. J. Hearne (chairman) said that during the war they kept Eire supplied with household hollow-ware. This trade was now experiencing certain opposition from pressed steel and aluminium ware. The company was the pioneer in Ireland of vitreous enamelling and it was clear that the finishes thus given to the products of the foundry were increasing in popularity among discerning users.

IN A LETTER to the National Union of Manufacturers regarding their representations on Imperial preference, the President of the Board of Trade says that the statement made in the House of Commons on December 6 by the Prime Minister still represents the Government's policy. The value of the preferences accorded and enjoyed by this country is not underrated, and these preferences will be contracted only as part of a general settlement which will be advantageous to this country.

FOLLOWING THE RECENT REDUCTION in price of the Government-owned stock of mercury metal, the Board of Trade have now decided that the import of mercury shall revert to private trade. Supplies of mercury may still be obtained from the Government store until such time as users are able to make their own buying arrangements. Users intending to make direct imports should submit an import licence application to the Import Licensing Department, Board of Trade, 189, Regent Street, London, W.1.

FOLLOWING THE ACQUISITION of the whole of the share capital of the Keenok Company, Limited, manufacturers of wet grinding and mixing machinery, of Stratford, London, E.15, by Vickers-Armstrongs, Limited, the board of the Keenok Company has been reconstituted as follows:—Mr. A. J. Palmer (chairman), Mr. C. W. Read-Baker (managing director), Mr. A. H. Hird, and Mr. E. J. Waddington. Technical sales will continue to be dealt with by Mr. L. A. Sonsthagen, and Mr. H. F. Compton will remain as chief designer.

LARGE-SCALE PLANS for the extension of railway electrification and for adoption of Diesel traction for subsidiary services have been announced by Sir Eustace Missenden, general manager of the Southern Railway Company. Expenditure on the new scheme is estimated to be in the region of £15,000,000. Electrification schemes already undertaken, Sir Eustace stated, saved some 400,000 tons of coal annually, and the new extensions, together with the adoption of Diesel traction, would result in a further saving of 300,000 tons of coal a year.

CONTRACTS OPEN

Any date given is the latest on which tenders will be accepted. The address is that from which forms of tender may be obtained.

Chippenham, December 13—Provision and laying of cast-iron water mains, together with valves, special castings, etc., for the Calne and Chippenham Rural District Council. Ross, Hooper & Harvey, engineers, Dallas Chambers, Chippenham. (Fee £1, returnable.)

Durham, December 31—Sanitary pipes and fittings; cast-iron gulleys, manhole covers and frames; tubular rail fencing, etc., for the County Council. Mr. W. J. Merrett, engineer and surveyor, County Surveyor's Office, 43, Old Elvet, Durham.

Witham, November 22—Supply, laying and jointing of about 5,500 yds. of 9-in. dia. iron water main, for the Urban District Council. Pick, Everard, Keay & Gimson, engineers, 6, Millstone Lane, Leicester. (Fee £2 2s., returnable.)

TECHNICAL EXHIBITION IN GLASGOW

A Technical Exhibition will be held in Kelvin Hall, Glasgow, from November 15 to 27. It will be opened by the Lord Provost of Glasgow, Sir Hector McNeill. The aim is to emphasise everything new in aids to increased production and so assist exports. Among the firms exhibiting are the following:—W. & T. AVERY, LIMITED, Birmingham; R. & J. DICK, LIMITED, Glasgow; GUEST KEEN & NETTLEFOLDS, LIMITED, Birmingham; ALFRED HERBERT, LIMITED, Coventry; MACROME, LIMITED, Alcester, Warwickshire; MIRLEES WATSON COMPANY, LIMITED, Glasgow; MORGAN CRUCIBLE COMPANY, LIMITED, London; A. REYROLLE & COMPANY, LIMITED, Hebburn-on-Tyne; JOHN SHAW, LIMITED, Worksop, Notts; THERMOTANK, LIMITED, Glasgow, and JOHN THOMPSON ENGINEERING COMPANY, LIMITED, Wolverhampton.

THE MODERN PIG

IF YOU WANT...
clean iron, free from sand, free from sows ...uniform analysis... convenient size...easy handling... specify STANTON MACHINE CAST PIG IRON

SPECIFICATION

WEIGHT	80-90 lbs.
Length	22 inches
Width	8½ inches
Thickness	3¾ inches

(at notch 2½ inches).

Made in our well-known

STANTON, HOLWELL & RIXONS BRANDS

THE STANTON IRONWORKS COMPANY LIMITED NEAR NOTTINGHAM

BRITISH BLAST FURNACES IN THE SEPTEMBER QUARTER

Number of Furnaces in Blast on September 28, 1946.

District.	Weekly average in blast, Sept. qtr.	Total in blast, Sept. 28.	In blast on September 28, making:			
			Hematite.	Forge and foundry.	Basic.	Ferro-alloys.
Derby, Leics, Notts, Northants and Essex	23.5	24	—	16	8	—
Lancs (excl. N.-W. Coast), Denbigh, Flint and Ches	4	4	—	—	3	1
Lincolnshire	13	13	—	—	13	—
North-East Coast	26	26	5	—	18	3
Scotland	10	10	1	6	3	—
Staffs, Shrops, Worcs and Warwicks	7·8	7	—	3	4	—
S. Wales and Monmouth	6·6	7	1	—	6	—
Sheffield	1	1	—	—	1	—
North-West Coast	5·8	6	5	1	—	—
Total	97.7	98	12	26	56	4

Weekly Average Number of Furnaces in Blast During the Previous Six Quarters.

District.	1946.		1945.			
	June.	March.	December.	September.	June.	March.
Derby, Leics, Notts, Northants and Essex	22.2	21.6	21.2	22.8	22.8	24
Lancs (excl. N.-W. Coast), Denbigh, Flint and Ches	4.5	5	5	5	5	4·6
Lincolnshire	12.9	12.4	13.4	13.3	13.3	14.1
North-East Coast	25.8	25	25	24.6	25.2	26
Scotland	10	10	10	10	10	10
Staffs, Shrops, Worcs and Warwicks	8	8.5	8.9	7.5	8	7.3
S. Wales and Monmouth	6.8	7	6.9	6.7	6.9	6.9
Sheffield	1.4	2	2	1.1	1	1.7
North-West Coast	6.6	7	7	6.2	6.5	7
Total	98.2	98.5	99.4	97.2	98.7	101.6

New Furnaces Building.

The following companies have furnaces in course of construction:—Colvilles, 1; Consett Iron, 1; Darwen & Mostyn, 1; Lancashire Steel Corporation, 1; R. Thomas & Baldwins (Redbourn), 1.

PERSONAL

MR. JOHN VICKERS, formerly foundry manager of Rolls-Royce, Limited, Hillington, Glasgow, and latterly a director and general manager of Renfrew Foundries, Limited, has resigned his position with Renfrew Foundries.

MR. S. W. WEST, of the X-ray division of Philips Lamps, Limited, has left London for the United States. He will join the North American Philips Company as technical manager of the X-ray division in the New York office.

MR. WILLIAM GWINNETT is shortly leaving for Adelaide, South Australia, where he will be director and works manager for Rubery, Owen & Kemsley (Pty.), Limited, a new subsidiary of Rubery, Owen & Company, Limited, motor and structural engineers, of Darlaston.

MR. J. WORTLEY FAWCETT, who recently relinquished his position as managing director of Firth-Vickers Stainless Steels, Limited, has been presented with an inscribed gold cigarette case, the gift of the staff. The presentation was made by Mr. Harry Green, who has had 50 years' service with the firm and its parent company.

ALDERMAN F. JAMIESON, secretary of the Preston branch of the Amalgamated Union of Foundry Workers, has been presented with an inscribed gold watch on his retirement after over 28 years' service. MR. W. J. COOPER, who recently retired, was treasurer for 34 years. He has been presented with an inscribed wristlet watch. MR. D. MARTLAND, received an electric lamp standard in appreciation for 23 years' service as check steward.

Wills

WILSON, O. C. a former Lord Mayor of Sheffield and chairman of the Sheffield Smelting Company, Limited £27,288

TAYLOR, JOHN, formerly joint managing director and vice-chairman of Mather & Platt, Limited, textile engineers, etc., of Manchester £263,361

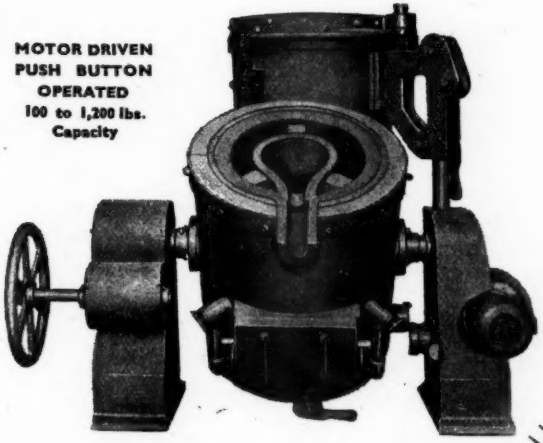
MR. D. F. CAMPBELL, chairman of the Electric Furnace Company, Limited, in a statement accompanying the annual report of the company, announces that a department for research and development of induction heating has been established, and much useful work has been done on heat-treating, heating for forging, and brazing.

CRUCIBLE FURNACES FOR NON-FERROUS METALS

"POLFORD"
REGISTERED

RAPID MELTING HOPPER ACTS AS PRE-HEATER GAS, COKE OR OIL FIRED
100 to 250 lbs. Capacity

MOTOR DRIVEN PUSH BUTTON OPERATED
100 to 1,200 lbs. Capacity



FLEXIBILITY OF CONTROL * LOW FUEL CONSUMPTION

SOLE AGENTS

THOS. W. WARD, LIMITED, Albion Works, Sheffield
TELEPHONE: 26311 TELEGRAMS: "FORWARD" SHEFFIELD

NEW COMPANIES

("Limited" is understood. Figures indicate capital. Names are of directors unless otherwise stated. Information compiled by Jordan & Sons, 116, Chancery Lane, London, W.C.2.)

Jonathan Shaw (Sheffield), Gibraltar Steel Works, Bowling Green Street, Sheffield—Iron, steel and scrap merchants. £3,000. A. H., E., D. A. and L. A. Wilson.

Wipac Repetition, 1, Queen Victoria Street, London, E.C.4—Manufacturers of component parts for general engineering purposes. £1,000. C. B. Jarman and E. Landon.

A. H. Westbury, rear of 11, Camp Street, Wednesbury, Staffs—Manufacturers of gas, water and steam pipes and fittings, etc. £1,000. J. F. and G. S. O'Neill.

Cranbore, Red Gate Street, Westfield Lane, Mansfield—Manufacturers of machinery, forgings, castings, tools, etc. £3,000. J. Wass, H. Ward, and W. H. Greaves.

E. D. Oakes & Company, 20, Cursitor Street, London, E.C.4—Manufacturers of hand and machine tools, etc. £1,000. E. D. and H. R. Oakes, and R. J. Felstead.

White & Carpenter, Mosley Buildings, 56, Mosley Street, Manchester, 2—Manufacturers of mechanical apparatus, etc. £3,000. G. M. White and J. Carpenter.

Fitson Products, Room 10, Third Floor, 317, High Holborn, London, W.C.1—General engineers, manufacturers of plant, tools, etc. £1,000. C. L. J. and G. E. Webb.

William Tomlinson & Sons, Crescent Ironworks, Shakespeare Crescent, Patricroft, Lancs—Constructional engineers, welders, etc. £2,000. F. E. and M. H. Myles.

Curd & Green, Broad Colney Works, London Colney—Manufacturers of metal components for engineering trades, etc. £3,000. L. W. Curd and R. B. Green.

Revelation Products, 30, Sevington Road, Hendon, London, N.W.9—Mechanical, electrical and general engineers, etc. £2,000. A. Ash, D. W. Simmons, and S. Brummer.

Page, Stammers & Porter, 11a, Grange Road, Hayes, Middlesex—Electrical and mechanical engineers, etc. £2,000. S. G. Page, E. A. Stammers, J. T. Porter, and A. J. Mitchell.

Norman Auriol, 4, Deans Yard, Westminster, London, S.W.1—Machinery and metal merchants, etc. £6,000. N. Leith-Hay-Clark, F. M. Campbell and M. A. Swaley.

G. H. Yule & Company, 85, Cox Street West, Balsall Heath, Birmingham—Manufacturers of machine and press tools, etc. £2,000. G. H. and E. Yule, and E. F. Preston.

British Peralta Company—Machine makers, founders, engineers, etc. £5,000. H. D. and C. I. Leather, L. Brearley, H. L. Grylls, and R. W. Leather, Wharfecote, Ben Rhydding.

Frankland & Duxbury, Holland Street Foundry, Holland Street, Accrington—Brassfounders and engineers, etc. £2,000. H. and E. M. Frankland, O. and E. Duxbury.

Nicrome, Jethro St. Works, off Ainsworth Lane, Bolton—Nickel, chromium, and electro platers, etc. £3,000. F. A. Boardman, H. L. Hunter, J. J. Pimbley, and J. J. Regan.

John Eccles & Company (Blackheath), 16, Culmore Road, Blackheath, Birmingham—Ironmasters, founders, and workers, etc. £1,000. J., G. A., and J. D. Eccles, and F. D. Pearce.

Power Jacks, 42, Valletta Road, Acton, London, W.3—Manufacturers of and dealers in machinery and mechanical contrivances, etc. £10,000. N. B. Newton and K. B. Jessop.

Streamline Heaters, Streamline Works, Langmead Street, Norwood High Street, London, S.E.27—Manufacturers of stoves, etc. £5,000. W. G. Finney and C. H. Kerr-Smiley.

Zirconal, 103, Cannon Street, London, E.C.4—Manufacturers of refractory articles and objects, tool, pattern and machinery designers, etc. £1,000. W. E. Smith and C. Shaw.

Alexander Kenyon & Company (Export Sales)—Manufacturing, mechanical, and general engineers, etc. £5,000. A. Simpson, 3, Shawbury Grove, Sale, Cheshire, subscriber.

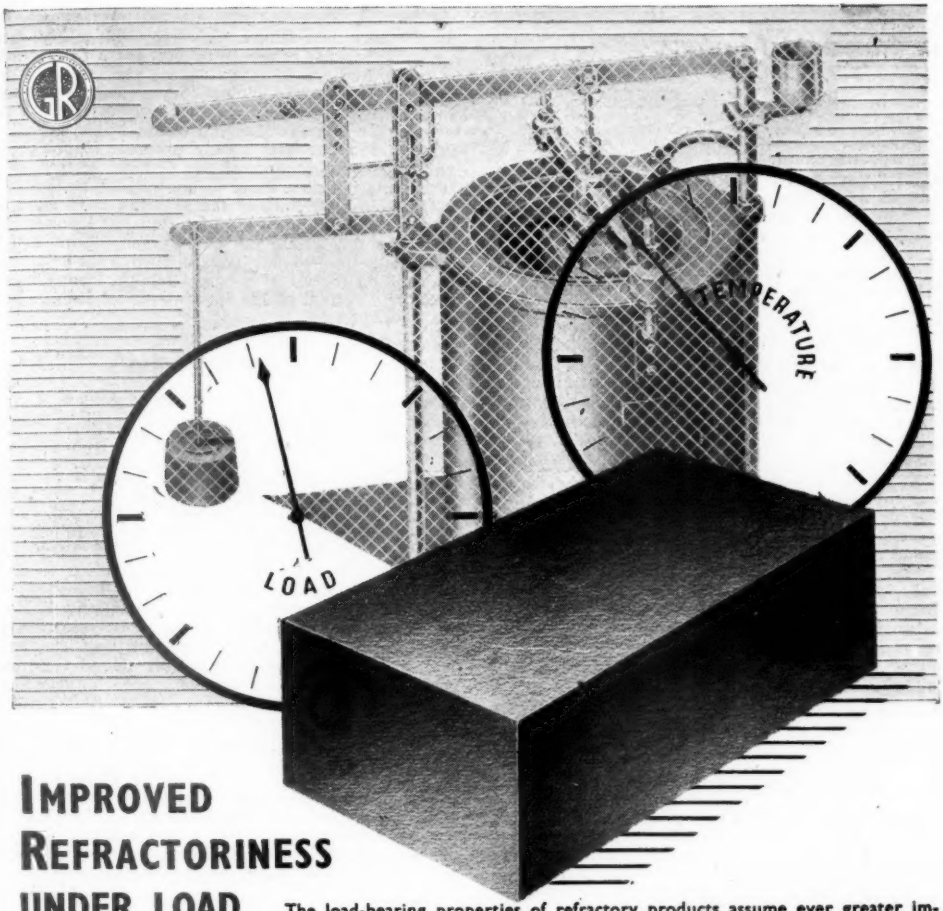
F. W. Pipe & Wynne Jones, Dowlais Chambers, West Bute Street, Cardiff—Engineers' merchants, etc. £5,000. R. E. W. Jones, C. A. and F. J. Pipe, and G. V. Wynne Jones.

Rowe Bros. & Company (Export), 33, Queen Street, Exeter—Machinery and metal merchants, etc. £25,000. W. S. G. Edgecombe, K. C. H. Rowe, R. D. Belcher, and G. N. Ditchburn.

Kineton Manufacturing Company, Warwick Road, Kineton, Warwicks—Engineers, machinery manufacturers, etc. £3,000. G. D. R. Davison, F. B. Saunders, and R. Creed.

Humber-St. Andrew's Engineering Company, St. Andrew's Dock, Hull—To acquire the businesses of Humber Shipwright Company, Limited, and St. Andrew's Engineering & Shipwright Company, Limited. £100,000. T. Boyd, H. Burton, W. G. O'Dell, M. Hellyar, A. Hudson, H. Precious, O. H. Henriksen, W. J. Robins, junr., C. H. Smith, and H. Wight.

THE REMARKS made by "Mr. Pearce" on page 114 of the current volume of the JOURNAL were those of Mr. F. C. Pearce, of Coventry.



IMPROVED REFRACTORINESS UNDER LOAD

AT HIGH TEMPERATURES

The load-bearing properties of refractory products assume ever greater importance in the design of furnace structures. This arises from the insistent demand for more efficient furnace operation and increased outputs, which entails the use of higher temperatures and heavier loads. General Refractories' products keep abreast of all requirements by the operation of a system of strictly controlled processing in which importance is placed upon raw material selection, grading and high temperature firing. Widely used throughout the country and overseas, G.R. products provide a complete answer to the vital need for strong, stable, and lasting furnace linings.

Advice on the selection and application of refractories is available on request.

FIREBRICKS · BASIC BRICKS
ACID-RESISTING MATERIALS
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Raw Material Markets

IRON AND STEEL

Applications for licences for pig-iron are closely scrutinised, but authorised tonnages are coming to hand fairly regularly, and if the output of foundry castings is well below requirements this is attributable to a shortage of labour rather than to a lack of material. Blast-furnace outputs have been stepped up by the more extensive use of high-grade imported ores, and there are still more stacks which could be put into commission if the need arises and the necessary fuel is provided.

Surprisingly, the September statistics reveal increased imports of steel semis from the United States. Maintenance of this pipe line is precarious and the price of American steel is high, but re-rollers are clamouring for more and the Control is doing its utmost to meet the demand. Sheet mills are fairly well supplied with bars and slabs, but there is still a pressing demand for billets for re-rolling into light sections, small bars, etc.

Users of steel plates and sections are getting fairly regular deliveries against current contracts, but it is increasingly difficult to place new orders, and it is suggested that some scheme of reauthorisation, such as has been applied to the sheet trade, may have to be devised. A feature of the specifications for plates is the preponderance of light material, and there is also a big demand for light and medium sections. For heavy sizes the call is a little less urgent, but there are many inquiries in circulation, while mills engaged on railway and colliery material will be fully employed throughout the winter months.

NON-FERROUS METALS

In order to bring the selling prices of copper and zinc in the United Kingdom more closely into line with current purchase costs, the Minister of Supply has made the Control of Non-ferrous Metals (No. 25) Order, which increases the maximum prices at which these metals may be sold in the United Kingdom. Under the new Order, which took effect yesterday (Wednesday), the maximum prices for copper, zinc and zinc products are increased as follow:—Copper by £14 per ton; zinc by £5; zinc sheets by £5, and zinc oxide by £4 5s.

Holders of valid licences to purchase copper and zinc metal (as sold by the Directorate of Non-ferrous Metals), granted on or before November 12, may, on application to the Directorate at 20, Albert Street, Rugby, cover themselves by purchases, where they have not already done so, against such licences up to and including November 30, at the maximum prices ruling on November 12.

The re-establishment of free trading on the London Metal Exchange does not seem likely to materialise in the very near future, although, with a free market in the offing for rubber, prospects for a resumption of normal trading in metals may be said to have brightened. In the United States there is a strong movement for a return of the open market.

The report of the Malayan Union Mines Loan Committee intimates that steady progress is being made with the rehabilitation of the Chinese section of the tin-mining industry. Prior to the war this section represented about one-third of the Malayan production. The Committee has approved more than 100 loans totalling approximately £400,000. Of this sum about half has been made immediately available, while the balance will be paid on receipt of progress reports from mines inspectors. A total of 252 applications for loans is before the Committee.

BOOK REVIEW

Industrial Injuries, by H. Samuels, M.A., and R. S. W. Pollard. Published by Steven & Sons, Limited, 119-120, Chancery Lane, London, W.C.2. Price 3s. net.

This book is one of the series "This is the Law," and treats a subject which is not yet quite the law, as the new Act which governs the question will not be in operation until the "appointed day." Injuries now occurring will be subject to the repealed Acts. As is well known, the new Act is quite different from the old. It is supported by those in non-hazardous employment as well as by those potentially liable to accident. Then there is to be no lump-sum payment, and the nature of the injury, and not the wage-earning capacity, is to be the major factor. Good features of the case are that litigation costs are eliminated, and the insolvency of the employer cannot affect payments to the injured person.

This book, in easily understandable language, takes the reader steadily through the main sections of the new Act, and explains in detail the procedure to be followed to receive the appropriate award. The reviewer recommends the purchase of this book by both employers and trade-union officials, as it is a thoroughly reliable statement as to the steps which have to be taken after the "appointed day."

V. C. F.

PATTERNMAKERS' STRIKE NOTICES

Members of the United Patternmakers' Association last week-end handed in notices that they will cease work in a fortnight's time. This was followed by an embargo on overtime as from Monday last. The men are demanding "incentive bonuses to bring up their pay to at least 3s. an hour." This demand compares with a current rate of 2s. 5½d. an hour.

THE WESLEY & CLARK ENGINEERING COMPANY, LIMITED, is being wound up voluntarily for the purposes of reconstruction. Mr. P. C. Molineux, Africa House, Kingsway, London, W.C.2, is the liquidator.